NOV 17 1941

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PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 152—No. 3953. *LONDON: FRIDAY, OCTOBER 17, 1941.* *Registered at the General Post Office as a Newspaper* PRICE 1s. BY FOREIGN POST 1s. 2½d.

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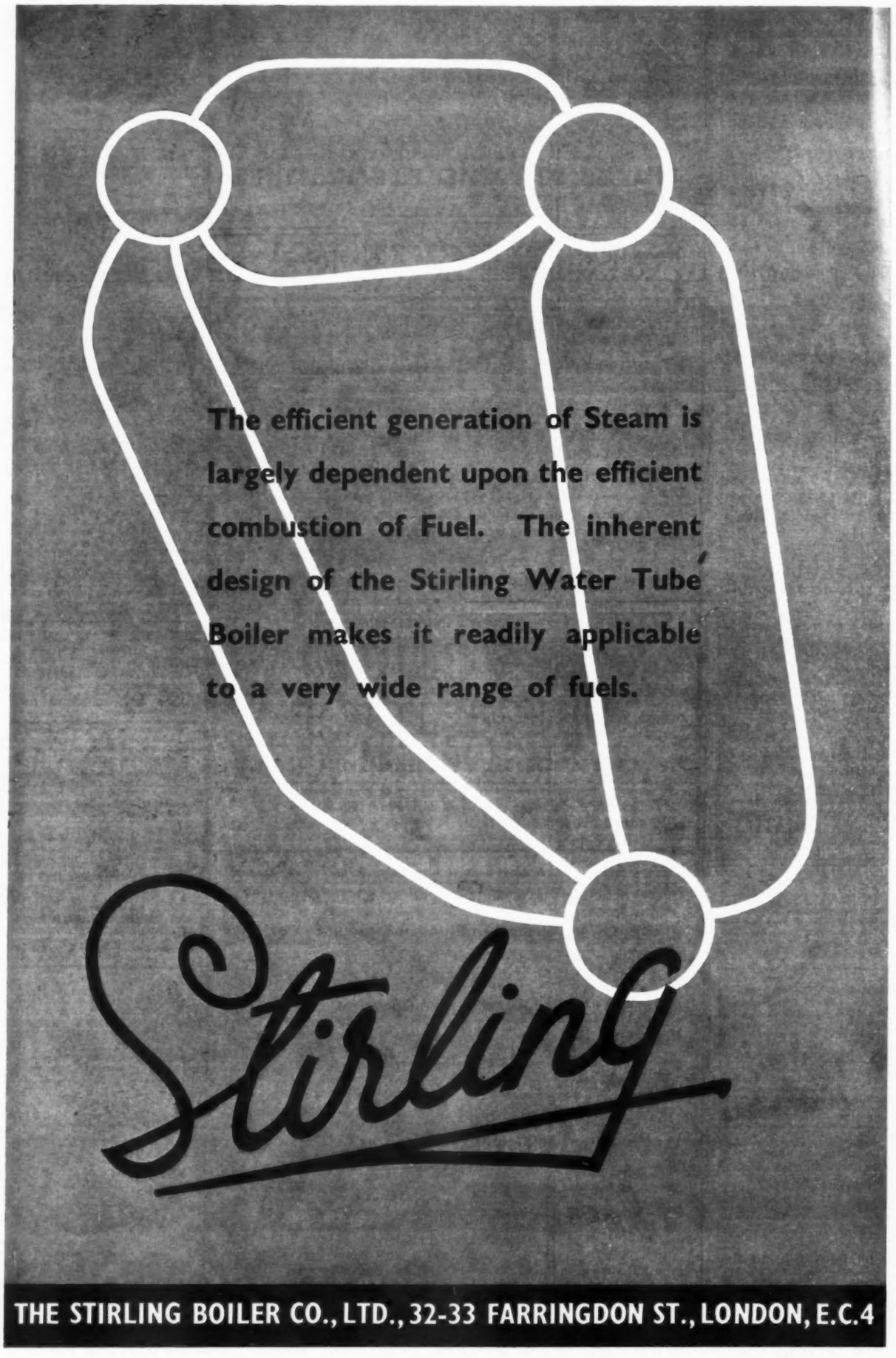
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THE STRENGTH OF CEMENT-LIME MORTARS AND CONCRETES.

By Dr. W. FISHER CASSIE, A.M.Inst.C.E.

THE addition of small quantities of hydrated lime to Portland cement concrete has long been recognised as sound practice. It has been thoroughly established, for example, that the addition of lime confers at least three benefits: it increases workability, decreases permeability, and prevents the segregation of the aggregates. The finer particles of the lime hydrate also retain moisture, releasing water slowly to the cement, and resisting evaporation. This circumstance tends to promote reasonably good hydration even under the adverse curing conditions often encountered in peace time, but more likely to occur now when little time is available for the finer points of concrete making. These facts are well established, and that such properties may be promoted in concrete by the addition of lime hydrate should be more widely known. When, however, the effect of lime on the strength of concrete is considered, considerable differences of opinion are met, and even completely contradictory statements. The following results, obtained by various experimenters, show how confusing are the data available for the information of engineers and contractors:—

Addition of 10 per cent. of hydrated lime to a 1 : 2 : 4 mix resulted in a 7 per cent. decrease in compressive strength.

Addition of 10 per cent. hydrated lime to a 1 : 3·4 : 6·6 mix resulted in a 12 per cent. increase in compressive strength.*

Addition of hydrated lime to the extent of 5 per cent. of the weight of the cement resulted in an increase of strength from 2,613 lb. per square inch to 3,816 lb. per square inch, or 46 per cent.†

Substitution of lime for an equal weight of cement cannot be expected to increase the strength of a cement mortar which is richer then 1 : 4.* The presence of 5 per cent. of hydrated lime in specimens made with coarse sand increases the compressive strength to some extent. In specimens containing fine sand, however, hydrated lime appears to decrease the compressive strength.†

In a report on the R.C. Elevated Roadway in Chicago, A. R. Lord said "Lime was not used from any faith in reported test data where an increase in strength due to other causes has been attributed to lime, but for practical reasons. We found that the use of 50 lb. of hydrated lime per yard batch of concrete had no observable effect on the strength of the concrete; and we have probably three thousand tests to judge from. We also found that the use of lime in this proportion made the concrete more workable, easier to place and less liable to segregation in transportation and handling. Past experience indicated that it decreases permeability, while twenty years' experience in its use in this manner has not confirmed any opinions to the effect that the lime will be carried away after the concrete is once properly made and placed."

Such wide divergence of opinion is confusing, and the evident lack of real knowledge of the effect of mixing lime and Portland cement in mortars and concretes has led to regrettable failures of air-raid shelters in various parts of the country. This article records the results of an investigation on the effects of lime additions to Portland cement mortars and concretes. The tests were made on four series of specimens. Series I consisted of cement-lime concretes of varying lime content. The tests on this series were concurrent with those on Series IV, which consisted of normal Portland cement concretes. These two series were tested for compressive strength. Two series of tests on cement-lime mortars were also made. Series II was tested for compressive strength, and Series III for tensile strength. Series II also furnished figures of use in estimating the modulus of elasticity.

Materials Used.—Aggregates and Sand: Fig. 1, on this page, shows the grading of the three materials used as aggregates in these experiments. The coarse and fine aggregates and the sand were mixed to give the grading shown by the dotted line in Fig. 1. This mixed aggregate was used in Series I and IV. This grading curve shows a material suitable for concrete, but it does not include the fine particles of the lime hydrate, which, in Series I, compensated for the slight deficiency in fines which the curve indicates.

Lime Putty and Mortar: For Series I, the lime was obtained as a lime putty. All mixing was done by hand, and it was found that, in these circumstances, the putty did not readily mix uniformly throughout the concretes of Series I. For Series II and III, therefore, the lime was delivered in the form of a wet lime mortar. This mortar had been mixed by a machine specially devised for delivering a ready mixed lime mortar, and tests showed that the material was uniform in composition, the sand and lime being thoroughly intermixed. The lime used was in the form of a hydrate made from the quicklime the analysis of which is shown below. This analysis indicates a high calcium, or "fat" lime such as is recommended by the Department of Scientific and Industrial Research for use in cement-lime mortars.

Analysis of Lime Used in Preparation of the Lime Hydrate.

		Per Cent.
Calcium oxide	CaO	98·17
Magnesium oxide	MgO	0·44
Silica, etc.	SiO_2, etc.	0·67
Ferric oxide	Fe_2O_3	0·06
Aluminium oxide	Al_2O_3	0·18
Carbon dioxide	CO_2	0·28
Sulphur trioxide	SO_3	0·20

The above analysis was taken from typical samples of material obtained regularly throughout the year. The lime was from Buxton. Repeated dehydrations in a muffle furnace, at a temperature sufficient to decompose the lime hydrate to oxide, showed that the lime putty of Series I contained 28 per cent. and the lime mortar of Series II and III, 18 per cent. of the gross weight as free water. The Portland cement complied with B.S.S. No. 12/1940.

Specimens.—Tests were made on a total of 84 specimens, each result being obtained from the mean of from 3 to 5 observations on similar test pieces. The composition of the mixes and the results obtained are given in Table I on page 303.

Series I. This series consisted of six different mixes of a lime concrete. Fig. 2 shows the variations in composition of the six mixes. The series was meant to show the effect of the replacement of cement by lime, the proportion of lime increasing as that of cement decreased. Water was added in order to make the total free water approximately 9 per cent. of the total weight, the weight of mixed aggregate being varied in order to give a consistent slump. It should be remembered that the proportions given are by weight, and the light and bulky lime putty had a much greater effect in altering the appearance and properties of the concrete than would appear to be indicated by the apparently low maximum content of 6 per cent. by weight. The specimens employed in this series consisted of 6 in. cubes.

Series II and III were identical in composition, each consisting of mixes of a lime mortar of constant composition, with the addition of quantities of cement varying from 9 per cent. to 35·5 per cent. of the total weight, as shown in Fig. 3. Sufficient water was added to bring the total free water to 22 per cent. of the total weight. The content of cement could not be reduced below 9 per cent. without reducing the strength of the mortar to negligible proportions. Series II was used in an investigation of the value of the modulus of elasticity, and the specimens were cylinders 3½ in. in diameter and 8 in. high. The specimens of Series III, which were tested for tensile strength, were of the standard cement briquette type.

Series IV consisted of six control mixes of Portland cement concrete, using the same mixed aggre-

Fig. 1.

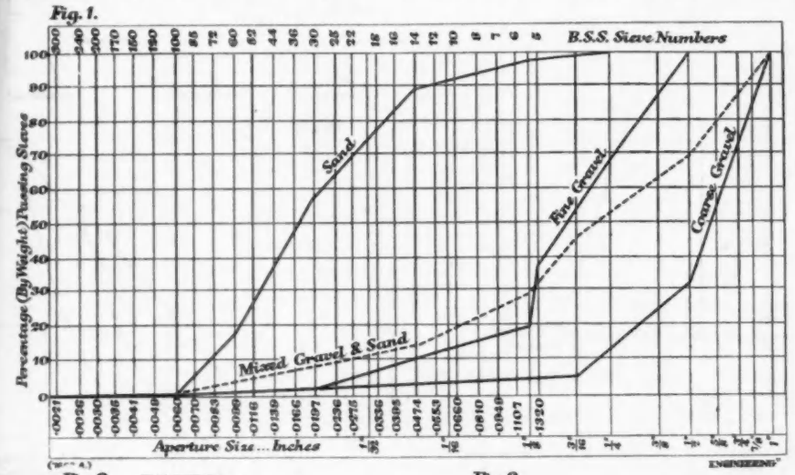


Fig. 2.

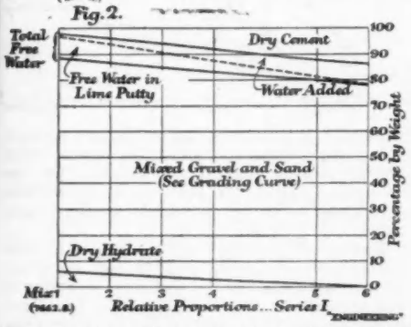
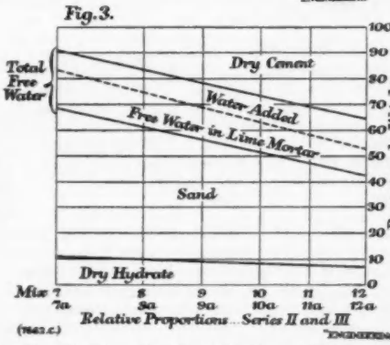


Fig. 3.



* R. P. Brown, "Use of Hydrated Lime in Concrete," *Cement and Engineering News*, Nov., 1923.

† Buxton Lime Firms, *Use of Limbux in Concrete Construction.*

* "Use of Hydrated Lime in Portland Cement Mortar," *Jl. Am. Ceramic Soc.*, Jan., 1925.

† H. F. Clemmer and T. B. Shirtzer, "Investigation of the Effect of Hydrated Lime in Concrete," *Proc. A.S.T.M.*, 1922.

STRENGTH OF CEMENT-LIME MORTARS AND CONCRETES.

Fig. 4.

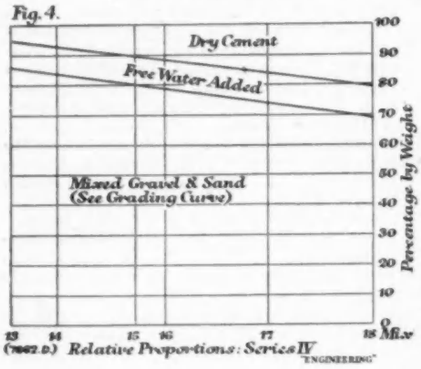


Fig. 5.

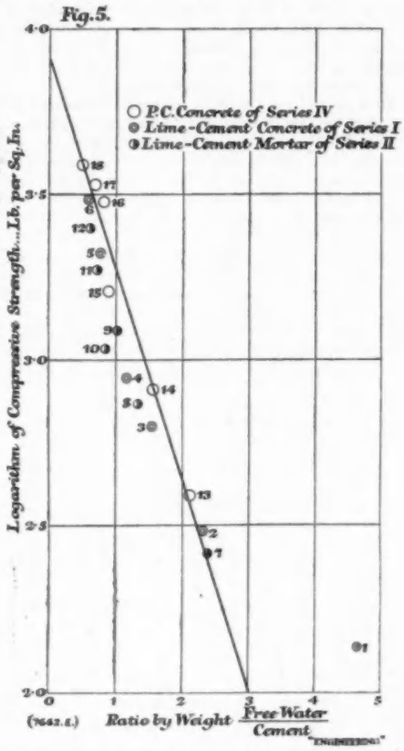

P.C. Concrete of Series IV
Lime-Cement Concrete of Series I
Lime-Cement Mortar of Series II
Logarithm of Compressive Strength...Lb. per Sq. In.
Ratio by Weight Free Water / Cement
"ENGINEERING"

Fig. 7.

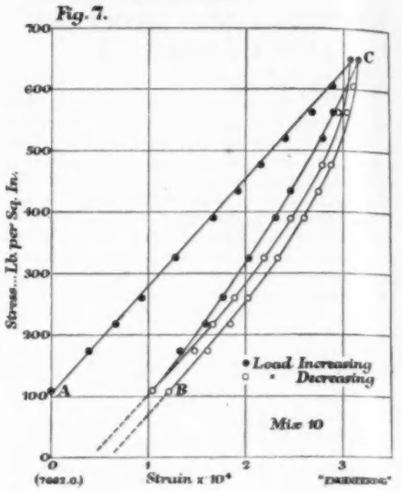


Fig. 6.

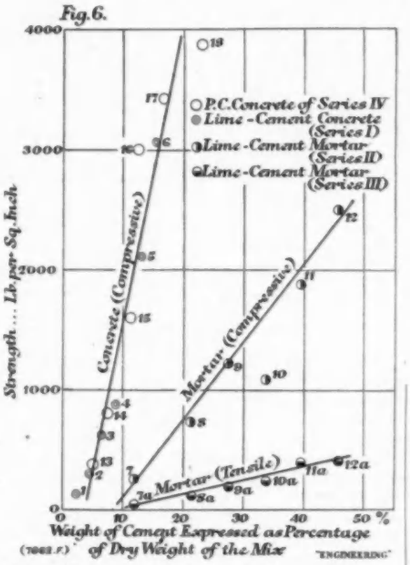
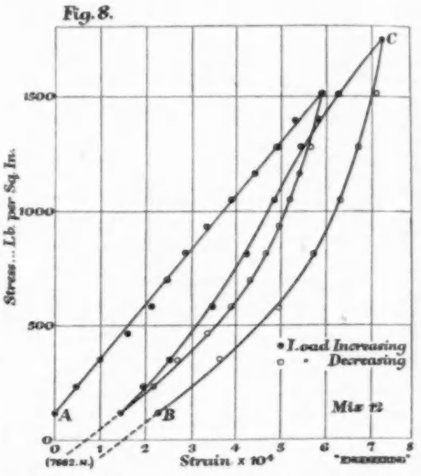

P.C. Concrete of Series IV
Lime-Cement Concrete (Series I)
Lime-Cement Mortar (Series II)
Lime-Cement Mortar (Series III)
Strength ... Lb. per Sq. Inch
Concrete (Compressive)
Mortar (Compressive)
Mortar (Tensile)
Weight of Cement Expressed as Percentage of Dry Weight of the Mix
"ENGINEERING"

Fig. 8.



gate and cement as is Series I, but without the addition of lime hydrate. The percentage of free water was again reasonably uniform, the average being 9·8 per cent. of the total weight. As in Series I, to which Series IV acted as a control, a consistent slump was maintained, and the specimens were 6 in. cubes. The proportions of this series are plotted in Fig. 4.

Curing and Testing.—Series IV was a sequence of normal concrete mixes, with varying water-cement ratios, from which it was possible to consider the effect of the addition of lime. In order that they should give normal strength results, the specimens of this series were thoroughly cured under water from the time of removal from the moulds until required for testing.

Series I and II, on the other hand, contained considerable quantities of lime hydrate, and, in order to allow of any possible strengthening which might be obtained from atmospheric carbonation, the specimens of these series were cured in dry air. All specimens of these three series were tested to destruction in a 100-ton Buckton testing machine, those of Series II, in addition, being investigated to determine the value of the modulus of elasticity

The specimens of Series III were cured wet and tested in a standard tensile testing machine for cement briquettes.

Discussion of Results.—Strengths obtained in compression and tension for the various mixes are shown in Table I, opposite. They were finally considered from two standpoints :—

(*a*) in relation to the water-cement ratio of the mix, and

(*b*) in relation to the content of Portland cement.

These two viewpoints bring out clearly the facts on which the strength of a lime concrete containing cement, or a cement concrete containing lime should be judged.

Strength. Water-Cement Ratio.—The well-known relationship, established by Duff Abrams, between S, the compressive strength of a concrete, and x, its water-cement ratio is

$$S = \frac{A}{B^x}$$

where A and B are constants depending on the specific concrete examined. The first step in the consideration of the results was to determine, by the method of least squares, the most probable values of the constants A and B for the concretes of Series IV. The relationship was found to be

$$S = \frac{8190}{4 \cdot 6^x}$$

and is plotted in a logarithmic form in Fig. 5, the straight-line curve referring to mixes 13 to 18 only.

Corresponding points for the mixes of Series I were then plotted on the same diagram against the relevant water-cement ratios. These water-cement ratios were obtained, as before, in terms of weight, using the figure of the total water content which comprised water added and the free water in the lime putty. It is at once evident that there is a close agreement between the results for Series I, and those for the control concretes of Series IV. On the whole, the points 1 to 6 are somewhat lower than those of 13 to 18, which may be accounted for by the necessary difference in curing conditions, and to some extent by an unavoidable difference in age, of one week, between Series I and Series IV. However, since both concretes were over two months old, any variation in strength over a week would probably be small enough to be within the experimental limits of accuracy.

The compressive strengths of Series II (Mixes 7 to 12) are also plotted in Fig. 5, and show a striking agreement with those of Series I and IV, despite the fact that some variation was to be expected on account of the difference in shape of the specimen.

Strength. Cement Content.—Fig. 6 shows the results obtained when the compressive strengths of Series I and IV and of Series II are plotted against the percentage of cement content, calculated on the weight of the dry materials in the mix. The lowest curve gives the results for the tensile tests of Series III. It is clear that the compressive strength of concrete, whether containing lime or not, varies directly with the cement content, and that the compressive and tensile strengths of cement-lime mortar also follow this trend less steeply. These are given in Table II, opposite.

Modulus of Elasticity.—By the use of a roller extensometer, on a gauge length of 3 in., the stress-strain relationship for the specimens of Series II was determined. The maximum stress was about 65 per cent. or 70 per cent. of the breaking stress, and, as shown by Figs. 7 and 8, the stress-strain curves followed the usual configuration for concrete under repeated loading, when the maximum stress is above the usually accepted value of the endurance limit (50 per cent. of the maximum stress).* Fig. 7 refers to Mix 10 and Fig. 8 to Mix 12. Typical curves are shown for these mixes, and, for the sake of clarity, only two repetitions of load are shown, though several more were made.

A B represents the permanent set after two repetitions of load, and the horizontal distance between B and C, the elastic strain. The stress-strain curve gradually "moves" to the right with repeated loadings, leaving a progressively larger permanent strain, A B, and becoming more concave towards the stress axis.† The initial tangent modulus (shown by dotted lines below B) becomes, after a few repetitions of load, somewhat less than its value on first loading. These properties of the stress-strain curves are all typical of normal Portland cement concrete (without addition of lime), and the

* W. F. Cassie, "The Fatigue of Concrete," *Jl. Inst. C.E.*, Feb., 1939.

† A. Mehmel, *Untersuchungen über den Einfluss häufig wiederholter Druckbeanspruchungen* (Springer).

actual values obtained for modulus of elasticity, although showing variation from mix to mix, were not sufficiently far removed from the usually accepted values for Portland cement concrete to enable a definite statement to be made that the presence of lime alters the modulus of elasticity.

The values of modulus of elasticity for specimens of Series II lay between $1{\cdot}5$ and $2{\cdot}0 \times 10^6$ lb. per square inch. As examples, the following figures are given for Mixes 10 and 12, the stress-strain curves for which are shown in Figs. 7 and 8 :—

Mix 10—First loading : $1{\cdot}9 \times 10^6$ lb. per square inch. Initial tangent modulus at B : $1{\cdot}5 \times 10^6$ lb. per square inch.

Mix 12—First loading : $2{\cdot}3 \times 10^6$ lb. per square inch. Initial tangent modulus at B : $1{\cdot}7 \times 10^6$ lb. per square inch.

TABLE I.—COMPOSITION OF MIXES, AND RESULTS OBTAINED.

Series Number.	Mix Number.	Mixed Sand and Gravel in Concrete. A.	Sand in Mortar. B.	Dry Lime Hydrate. C.	Portland Cement. D.	Total Free Water. —	Water-Cement Ratio.	Percentage of Cement Calculated on Dry Weight of Mix (A, B, C, D).	Compressive Strength, lb. per square inch.	Tensile Strength, lb. per square inch.	Age at Test.
		These figures are percentages on total Weight, including Free and Combined Water. Total : 100 per Cent.									
I	1	82·3	—	6·1	2·1	9·5	4·64	2·3	137	—	9 weeks
	2	81·4	—	5·1	4·1	9·4	2·32	4·5	305	—	
	3	80·4	—	4·2	6·0	9·4	1·55	6·6	630	—	
	4	79·5	—	3·3	8·0	9·2	1·16	8·8	880	—	
	5	77·7	—	1·6	11·7	9·0	0·77	12·9	2,110	—	
	6	78·0	—	0·0	13·9	8·1	0·58	15·3	3,060	—	
II	7	—	57·6	11·2	9·2	22·0	2·39	11·8	261	—	9 weeks
	8	—	51·5	10·0	16·5	22·0	1·33	21·2	733	—	
	9	—	47·4	9·2	21·4	22·0	1·03	27·4	1,222	—	
	10	—	43·4	8·4	26·2	22·0	0·84	33·6	1,080	—	
	11	—	39·6	7·7	30·7	22·0	0·72	39·4	1,874	—	
	12	—	35·4	7·1	35·5	22·0	0·62	45·5	2,500	—	
III	7a	—	57·6	11·2	9·2	22·0	2·39	11·8	—	52	14 days
	8a	—	51·5	10·0	16·5	22·0	1·33	21·2	—	124	
	9a	—	47·4	9·2	21·4	22·0	1·03	27·4	—	204	
	10a	—	43·4	8·4	26·2	22·0	0·84	33·6	—	243	
	11a	—	39·6	7·7	30·7	22·0	0·72	39·4	—	387	
	12a	—	35·4	7·1	35·5	22·0	0·62	45·5	—	406	
IV	13	86·0	—	—	4·5	9·5	2·13	5·0	390	—	10 weeks
	14	83·9	—	—	6·7	10·4	1·56	7·5	810	—	
	15	80·7	—	—	10·2	9·1	0·89	11·2	1,600	—	
	16	79·6	—	—	11·2	9·2	0·82	12·3	3,000	—	
	17	74·9	—	—	14·8	10·3	0·70	16·5	3,420	—	
	18	69·4	—	—	20·4	10·2	0·50	22·8	3,870	—	

Types of Specimens : Series I and IV : 6 in. cubes. Series II : 3½ in. diameter cylinder, 8 in. high. Series III : Cement briquettes (B.S.S. 12).

TABLE II.

—	Increase in Strength for 1 per Cent. Increase in Cement Content.	Type of Material.
Series I and IV	250 lb. per sq. in.	Cement-lime concrete with 9 per cent. to 10 per cent. water.
Series II ..	65	Cement-lime mortar with 22 per cent. water.
Series III ..	12	Cement-lime mortar with 22 per cent. water.

Summary.—Strength-water-cement relationships for cement-lime concretes were tested against a similar relationship for normal Portland cement concrete. It was found that the agreement was good. The line in Fig. 5 refers to the normal concrete, the other points being inserted later, but it is evident that a common curve could be obtained for them all, in which case the discrepancy shown by any one point would be even less than in Fig. 5. The strengths of mortars of wet consistency, and containing lime, also agree closely with those of the concretes. A similar close agreement between concrete strength and the strength of wet mortars has already been shown by Glanville for Portland cement mixes,* thus giving further indication that the presence of lime does not disturb the strength-water-cement relationship.

The second fact on which an estimation of the strength of cement-lime mortars and concretes may be based is that the compressive and tensile strengths increase directly with increase in cement content (the water content being constant). Here, again, the figures for cement-lime concrete show little or no variation from those of Portland cement concrete. The stress-strain curves for cement-lime mortar under several repetitions of load, show the same characteristics as do normal Portland cement mixes, and the value of the modulus of elasticity is not significantly affected by the presence of lime.

All these results, over the four series of tests, point to the conclusion that the strength of a cement-lime mortar or concrete must be estimated from its cement and water content. Trial mixes made without the addition of lime will give similar results to mixes of which hydrated lime is a constituent part. One is thus compelled to agree with A. R. Lord that any increase in the strength of concrete which has been attributed to the presence of lime, was, in fact, due to other causes (*e.g.*, water content), and that, at least up to the age at which concrete may be expected to carry its full design load, the lime acts as an inert filler, beneficial in several ways, but not contributing to the strength of the mix.

The author is indebted to Messrs. Lime-Sand Mortar, Limited, Newcastle-upon-Tyne, who supplied the materials for this investigation, carrying out the slaking of the lime putty for Series I and the machine mixing of the lime mortar for Series II and III.

* W. H. Glanville, "Mortar Tests as a Guide to the Strength of Concrete," *Structural Engineer*, May, 1934.

CHADWICK PUBLIC LECTURES.—The autumn programme of the 29th annual series of Chadwick Public Lectures is devoted mainly to public health subjects. On Tuesday, October 28, at 2.30 p.m., Mr. J. C. Dawes, O.B.E., M.I.Mech.E., of the Ministry of Health, will lecture on "The Cleansing of Towns and Cities" at the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1. The Bossom Gift Lecture will be delivered on Tuesday, November 11, at 2.30 p.m., at the London School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, London, W.C.1. The lecturer will be Mr. F. R. Hiorns, F.R.I.B.A., F.S.A., and his subject, "Hygiene Technique in Building, or the Economic, Psychological and Health Aspects of Surface Treatment." The last lecture on the programme is entitled "Post-War Housing in the Light of War-Time Experience." This will be delivered by Mrs. Blaise Gillie, of the Society of Women Housing Managers, at 2.30 p.m., on Tuesday, December 9, at the Royal Society of Tropical Medicine and Hygiene, 26, Portland-place, London, W.1. Admission to all the lectures is free, and tickets are not required. Further particulars regarding the Chadwick Public Lectures may be obtained from the Secretary of the Trust, 204, Abbey House, Westminster, London, S.W.1.

FOREMANSHIP TRAINING IN THE UNITED STATES.

By F. J. BURNS MORTON.

AMERICA can be rightly regarded as the birthplace of foremanship training, not necessarily because it was there that the idea was first promoted, but rather because of the considerable attention given in that country to the problem, the widespread acceptance of the need for, and the adoption of, courses of training, and the immense growth in the technique of developing foremanship capacity. It is for this reason, coupled with the increasing recognition of, and demand for, foremanship training in this country also, that a review of American experience and methods may be of value at the present time in guiding British practice and procedure. The significance of foremanship first achieved general recognition when Taylor developed his plan of functional supervision as an integral part of scientific management. Appreciating both the importance of the task and the inability of the average foreman to fulfil it satisfactorily, Taylor contended that the work should be divided among a number of functional specialists. During this phase, ability could be acquired only through the hard school of practical experience.

The original attempts to improve the standard of foremanship were made during the war of 1914-18, when, under the stress of emergency, some form of rapid training became essential. During the post-war years, 1920 to 1929, when new products and new processes were being developed to meet new markets, and greater output was needed to meet expanding demand, stress was placed on continuity of production and regularity of employment, resulting from effective planning. The years of depression which followed from 1929 to 1933, emphasised the outstanding need for cost and quality control, to meet reduced demand and increased competition. From 1933, the period of recovery, punctuated by the Roosevelt National Recovery Acts, was first marked by uncertainty and friction in employer-employee relations, but later led to widespread expansion in business.

Throughout the whole of these topsy-turvy years there was growing in America a greater expansion of business and a rapid development in organisation. As conditions changed and emphasis was in turn placed on certain prominent aspects, new devices were developed for the control of output, costs, quality, materials, planning, progressing and labour. The rapidly increasing size of the business units produced new problems in the delegation of authority and responsibility. The widespread adoption of functional specialists affected greatly the scope and influence of the workshop foreman. New means of communication, co-ordination, collaboration and co-operation had to be devised. The immense expansion of the technical aspects of business and organisation, almost to the exclusion of personnel considerations, led to an ever-widening gap between management and men. An attempt was made to bridge this gap by introducing and increasing the influence of the personnel department through "welfare schemes." The casual, superficial, and supplementary influence of such schemes was soon to be recognised when widespread labour troubles raged unabated. It was realised that industrial contentment was not to be found in Government stipulations for regulating employer-employee relations, in trade-union agreements, or in the observance of any general rules and regulations. There must be real understanding, which means recognition of the individual; and this infers personal day-to-day contacts, which can be effected satisfactorily only by the foreman.

The great expansion of industrial activity, the rapid development of mass-production methods, the higher individual efficiency, the improved technical processes, and the increased complexity of modern organisation have all emphasised the outstanding importance of foremanship. The swiftly moving changes in social conditions, the growing independence of the employee through trade-union representation, and the personal influence exercised by the foreman, have also directed attention to his careful selection, training, promotion, remuneration

and status. Such tendencies and trends, already well-established, are now being accentuated and accelerated under the impetus of present-day war conditions. Foremanship training in America, it might be concluded, arose from the impelling need for increased productive capacity and the incessant demand for improvement in industrial relations.

One of the high-lights of foremanship training development is the Western Electric Company's experiment, conducted at the Hawthorne Plant in Chicago between 1927 and 1932, which involved the individual interviewing of 21,000 employees to ascertain their reactions to working conditions. This investigation forcibly emphasised that the greatest improvement in production could be best effected by training the firm's 1,000 supervisors to exert more effective influence over the employees. This investigation was carried out by members of the staff of Harvard University. It received wide-spread attention and added much impetus to the movement in favour of training supervisors.

Some idea of the wide application of foremanship training in America can be seen in surveys made recently. In 1929, an investigation was made by the National Metal Trades Association which showed that, of 900 concerns, 47 per cent. had training programmes. In 1931, in a survey made by S. B. Mathieson and covering 195 industries with 2,191,000 employees, it was found that 34 per cent. had foremanship training programmes. In 1934, the National Industrial Conference Board reported that, of 233 companies analysed, 47 concerns were maintaining courses, 100 were holding conferences, and 30 had committees working. In 1936, the same Board covered in a similar way 2,452 companies, representing 4,502,608 employees, and found that, although only 185 firms had training programmes, these firms represented 32·8 per cent. of the employees dealt with in the survey. There is a clear indication, therefore, that foremanship training has been adopted for the most part in the bigger firms. Since 1936, however, there has been a marked increase in the number of firms, large and small, that have adopted a definite training scheme for their foremen; and this is due largely to recent labour legislation, an example of which is the National Labour Relations Act, which governs employer-employee relationship. A survey dealing with one city alone was carried out by the Philadelphia Chamber of Commerce in 1937, and showed that 56 firms then had some type of training programme.

The American problem is similar to our own. Delayed for a considerable period before the final decision for defence was reached, an enormous expansion of war industries was eventually undertaken with exceptional speed. Some idea of the scale of this expansion is afforded by the Curtis-Wright Corporation, which, in July, 1941, occupied more floor space than existed in the entire aircraft manufacturing industry of the United States in September, 1939. Such rapid development calls for a greater measure of administrative control, better managerial practice, more complex organisation, and the necessity for up-grading supervisory personnel. Then, too, the unusual circumstances of production, together with the great scarcity of trained labour, provided employees with opportunities for demanding wage increases, for securing new privileges, and for stirring up trouble through the organised unions. Under such conditions the foreman can be of paramount importance. The technical aspects of production now are infinitely more difficult than hitherto, and, in addition, suitable labour must be engaged, trained, placed, and handled with far greater care and consideration than previously. Not only must there be better supervision, but there must be more and better supervisors. The significance of this problem has been realised by the Council of National Defense, whose Advisory Commission, at the end of 1940, made recommendations for improving supervisory practice through training by the conference method.

A review of American practice emphasises two striking conclusions: first, the United States Government has taken a leading interest in the training of foremen in industry, stimulating rather than forcing its development; and second, training is regarded and accepted as the responsibility of employers, rather than as the free choice of employees who are seeking promotion. The United States Department of the Interior, under the provision of the Smith-Hughes Act of February 23, 1917, set up the Federal Board of Vocational Education, charged with the responsibility of making studies and investigations, and publishing reports, designed to aid the States in the organisation and operation of efficient vocational education. The training of foremen was recognised as an important part of industrial education. Although the primary concern of the Board, the work of which was greatly extended under the George-Deen Act of 1936, was to act in an advisory capacity to industrial concerns and educational authorities, the Board also undertook the training of suitable conference leaders. In directing attention to the need for training, in publishing books and pamphlets, and in advising on the method and material for successful conferences, immense assistance has been rendered by the Government, through its official attitude in offering support, advice and leadership in the problem of foremanship training.

Both Government and industry, in directing foremanship training along the right lines (in fact, preparing for a period of progress and prosperity) were ensuring the utmost flexibility in meeting future requirements, securing understanding and contentment in the daily task, and stimulating personal efficiency in business, by their widespread installation of trained executives. It was part of the national policy; for, as President Coolidge said, "The business of America is business."

After twenty years of experience in foremanship training, American industry realises that satisfactory and permanent results cannot be achieved overnight. Foremanship is an educational process which develops gradually, for not only does it take time for the foreman to acquire the necessary technique, but he must also change his mental outlook to suit the new conditions. Firms that adopt a programme of foremanship training must be able to foresee and contend with innumerable difficulties and must exercise patience in awaiting results. Success comes most quickly when the right method is applied in the right way at the right time, and a review of American practice and procedure goes far in demonstrating the best methods to adopt.

The significance, both socially and industrially, of better management must not be under-estimated in the changing circumstances which give greater power to labour, with increasing independence of the individual worker, and a growing demand for the greater control by employees over the conditions of their employment. It is of great importance that management and supervision be exercised with more intelligence, foresight, and sympathetic understanding than ever before, if industrial and structural authority are to be maintained in their present form. It is only through such methods of management that it is possible to avoid control by committees, decisions by conferences, and increasing interference by more exacting legislation.

The necessity for foremanship training in America finds its fundamental support in the universal belief that education has its just reward; which incidentally, is a conception more widely accepted in Scotland than in England. In America, too, there is a strong belief in the democratic principle of equality of opportunity, and this is amply justified by a rate of individual progress unknown in Europe. Consequently, the drive for personal efficiency by employers on the one hand, and the desire for promotion by employees on the other, have produced the complementary conditions essential for training. Progress of the firm and promotion of the individual go hand in hand where both are adequately prepared for future possibilities, so that training, as one writer puts it, is a "basic philosophy of management."

Development is the keynote of the American industrial future. It is being pursued by an expansion and extension of activities, coupled with greater and still greater internal efficiency. Progress is marked by the increasing complexity of operation. Rough-and-ready operations are abandoned in favour of scientific method, and there is a greater attention to, and control over, detail. As a result, the business unit is becoming more sensitive and susceptible to changing conditions, so that planning ahead is a vital necessity. It is realised, therefore, that, if development is to continue unimpeded, the rate of progress must be entirely regulated by the capacity of the management, including the foremen, to respond to the demand for improvement. While the upper strata of management, because of their better general education and more precise training, are able to adjust themselves, it is found in practice that similarly rapid changes are not possible with supervisory staff. But with a rapidly expanding company it is better to promote from within than to engage from outside, and it might be concluded therefore, that if a company is bent on development and has decided on a progressive, profitable and permanent future, it must close the ever-widening gap between management and foremen; it must prepare its existing staff and promote from it; and it must ensure that the standard of executive direction is equal to the expanding activities. All this is done by means of foremanship training.

With the increasing rapidity of changes, with the introduction of new systems, and with adjustments in procedure to meet ever-changing demands, it is more than ever necessary to maintain a close co-ordination and a more intimate collaboration within the organisation. As firms grow, there is a widening of contacts, there arise conflicting instructions, and there is an attempt at such forms of control as frequently lead to misunderstanding. The training of foremen by the conference method tends to overcome these objections, for frequent meetings are usefully employed to convey information, to engender a proper outlook, to provide opportunity for discussion, to disseminate policies and instructions, to ensure uniform application of procedure, and to stimulate enthusiasm. Such a measure as this tends to overcome the remoteness of personal influence and the growing absence of personal leadership, which are outstanding weaknesses in large-scale organisations.

A well-organised administration implies full recognition and support of the status, responsibility and authority of each of its foremen. The foremen should be taken into the confidence of the higher management, and should be advised before changes take place, rather than allowed to find out about them afterwards. The foremen should be given the detailed information necessary for them to control their departments, and this means that they must develop, or be helped to develop, the ability to use statistics intelligently and effectively. It is so easy to view technical and other changes from the wrong viewpoint that it is necessary to make sure that they are fully appreciated and accepted without question by the authority responsible for their operation. Foremen also should be expected to make suggestions for improvements; but, once again, such suggestions can only be obtained through proper encouragement. It is perhaps for the reason of growing technological development that the Metropolitan Life Insurance Company's Policyholders Service Bureau gives the three main objectives of foremanship training as: (*a*) providing foremen with the opportunity to acquire information; (*b*) helping them to think clearly about their jobs; and (*c*) developing ability in doing what is required of them. The desire for these achievements, and the justification of them is fully appreciated by those who have tried to improve quality of workmanship by stressing the great importance of customer outlook.

(To be continued.)

The United States Petroleum Industry.—The output of crude oil in the United States continues to increase. Production during the week ending September 13 averaged 4,033,700 barrels daily, compared with 3,814,950 barrels in the preceding week.

Railway Goods Wagons for South Africa.—The South African Railways and Harbours Administration is expecting that the delivery of 2,700 goods wagons, ordered from overseas, will commence at the end of the present year. Of these 700 are being manufactured in Great Britain and 2,000 in Canada.

FUNDAMENTAL PROBLEMS OF ENERGY.*

By Dr. HERBERT CHATLEY, M.Inst.C.E.

SPEAKING broadly, all the sources of power available to man derive directly or indirectly from the sun. Solar energy is principally received as radiation, amounting to two calories per sq. cm. per minute when the sun is overhead and the air is fully transparent. This is equivalent to about 1¼ kW per sq. m., but, owing to clouds, absorption in the atmosphere, departure of the sun from the zenith and the absence of the sun during the night, the mean effect is rarely more than one-quarter of this. Most of the energy is converted into the latent heat of water vapour, the warming of the soil, or the expansion or kinetic energy of the air and is ultimately lost again by the earth's radiation into space, the average temperature of the earth's surface remaining at a practically constant value determined by a nice balance between this incoming radiation from the sun and the equal but opposite radiation from the earth. There is, however, some storage of energy in organic materials, elevated water, and a very few mineral forms which, in fact, form our principal and definitely limited resources.

It may be computed that each sq. cm. of the sun's surface is pouring forth $6{\cdot}24 \times 10^{10}$ ergs per sec., or about 6 kW. The temperature there is of the order of 6,000 deg. C. and there is reason to think that this process has been going on for something like 10,000 million years. The actual output per gram per second is, contrary to popular belief, very small—only some 2 ergs. Small as this is, continued for this prodigious number of years, it totals to some 10,000 kWh per gram, as compared with about 0·002 kWh per gram for very active combinations of chemicals. Thus, the average substance of the sun has a total energy production some millions of times greater than that of earthly fuel combinations, but its activity (power rate) is extremely small. It seems probable that a central temperature of the order of 20,000,000 deg. C. is consistent with a gradual transformation of hydrogen into helium, carbon acting as a kind of catalyst, the radiation deriving from a small loss of mass in the hydrogen. In stars other than the sun there are some cases in which the rate of output is higher. The faint star known as HD1337A is reputed to have an output of 15,000 ergs per gram per second, but even this is extremely small compared with earthly fuels.

Within the earth there are minute quantities of certain substances, particularly the elements uranium and thorium, which are gradually transformed into simpler elements (principally lead). Of these, the intermediate form—radium—is one of the most stable and gives off in the course of some 3,000 years much the same energy as the sun's average material. The output per second is of the order of a million ergs per second per gram, but even so this is only about one ten-thousandth of a kilowatt per gram. Since a gram of carbon-oxygen mixture will produce about 2,000 calories of heat, equivalent to 80,000 million ergs, or about one 500th of a kWh, and can easily be burnt in, say, 36 seconds (one hundredth of an hour), it can produce as heat one-fifth of a kW, vastly exceeding the *rate* of output of the radium. Hence, even radium, were it to be obtainable in large quantities, would not be at all a convenient form of power, in spite of the fact that the power would last for thousands of years.

While the cosmic sources are prodigious, they are very slow in action, and the chemical combinations on earth are capable of producing power at a far greater rate per unit mass. In ordinary fuels such as coal with comparatively small surface per unit mass, the contact with the air is limited and combustion is slow. With powdered fuels and a liberal air supply entering into the powder, combustion may be rapid, rising, in the case of fine coal-dust suspensions in air, to explosive conditions. Similarly, if oxygen-producing chemicals are mixed with carbon dust, as in the case of black gunpowder, the activity is very high. With high explosive the comminution is on a molecular scale, so that the combustion is only a matter of atoms changing position in the individual molecules; hence, the essential feature is usually a nitrogen compound which readily changes with fulmination (initial breaking down by another more unstable chemical change) or shock into a more stable form, often mainly simple nitrogen gas. The difference between the energy of combination of diatomic nitrogen and that of the original form is not often as high as that of carbon or hydrogen with oxygen, but the surface over which the change can occur is so enormous that the process is almost instantaneous. If, for instance, the molecules of a high explosive are one ten-millionth of a centimetre in diameter, one cubic centimetre contains one thousand million million million molecules and the mutual surfaces of contact are of the order of ten million square centimetres or one thousand square metres. It is quite feasible for such materials to give off energy for a fraction of a second at a power rate of thousands of horse-power per pound.

The natural storage of energy is either chemical or hydrostatic. In the case of coal or wood, solar radiation is stored in endothermic forms produced by the disintegration of carbon dioxide and water in plant life. Oil appears to have been largely due to animal (fish) life of former times and the formation of sulphur is an indirect process (possibly bacterial) which occurs in volcanic areas. As to hydrostatic storage, it need scarcely be remarked that this is due to solar radiation causing evaporation. Radioactivity is infinitesimally diffused, from an engineering aspect, and need not be considered. Artificial storage may take many forms but, with the exception of reservoirs, all are very inefficient. This serves to emphasise the overwhelming importance of fuels as the one reliable source of means for supplementing human effort.

The imports of mineral oil, some 11 million tons annually, are paid for by coal-produced manufactures or indirectly by the actual export of coal, so that, contrary to the popular belief, they do not add to our power resources, but simply put some of them in a form which is more convenient for certain purposes. The actual quantity of coal used for power purposes is something like 120 million tons per annum (about 2 tons per acre of the whole island of Britain), or, say, 3 tons per head. Whereas, in labour and transport, coal of fairly good quality in the neighbourhood of London costs per ton the equivalent of about 48 hours in unskilled wages, its labour product, even in rather low-efficiency steam plant, is some 400 horse-power hours or about 4,000 man-power hours. In other words, even on a conservative reckoning, the power content of a ton of coal is some 80 times as great as the labour power required to win and carry it. Allowing as much as 100 per cent. on the latter for the minding of the plant and the wear and tear on same, we still have a figure of 40 times, which will be much increased with high-efficiency plant and cheap dust coal. This difference is the main factor in the benefits of industrial civilisation. It is the source of the high standard if living, the short hours, the social services, the dividends of shareholders, the political and military position of Britain and all the other things which we think are due to our own cleverness.

In terms of present labour costs, the true value of a ton of good coal is about 100*l.*, or, to go to the other extreme, the value of a week's unskilled routine work of 48 hours is only about 1*s.*, that being the present market price of the coal which will do the same amount of work. In modern factory design, it is well known that it will pay to invest about 500*l.* in extra mechanical plant in order to save one workman. Since a perpetual annuity of about 20*l.* a year can be bought with the same sum, and the coal required to replace the man's actual energy is less than 1 ton per annum, it is easy to see that practically the whole of the public service and the profits arising from the factory system actually derive from the low price of coal. This leads to another conclusion which is not at all welcome to certain parties, namely, that the export of coal at the mere cost of winning and transport is ridiculous. For every ton of coal we export, we are giving away future productive power, and only in a few cases (as with the purchase of oil) do we get a partially equivalent return.

Prior to the Nineteenth Century, the coal raised in England was very small in quantity, and was used practically entirely for domestic heating. The combined effect of technical developments and the machine factory was to raise the coal output during the century from a few million tons per annum to over 250 million tons in 1913, since which time it has remained at about that level. It is generally agreed that the present consumption can be maintained for several hundred years. On the other hand, the average depth from which coal has to be raised is steadily increasing, and while the cost is somewhat offset by the use of machinery for cutting, pumping, ventilating and hoisting, the difficulties of winning must increase with time.

(To be continued.)

* Chairman's address to the Junior Institution of Engineers. December, 1940. Abridged.

PACKING OF GOODS FOR THE MEDITERRANEAN.—The Minister of War Transport states that cargo, packed in cartons, arriving in the Mediterranean is often in a bad condition. It is urged that such packages be strengthened with wire.

PROFESSIONAL FEES FOR WAR-DAMAGE REPAIRS.—In agreement with the Royal Institute of British Architects and the Chartered Surveyors' Institution, the War Damage Commission has issued a scale of fees which it will allow for professional advice in claims for payments for the costs of works or temporary works in connection with war damage.

REVERSIBLE MAGNETIC COUPLING.

As the magnetic coupling is inherently flexible, it is particularly suitable for use in Diesel-engine driven ships and has found considerable application in that field. It enables the engines to be started under no load, the torque being gradually applied after the engine has been run up by switching-in the coupling excitation. The arrangement is very convenient during reversal, and by de-energising the coupling the engine may be reversed under no load. In the case of more than one engine driving a common propeller shaft, the flexibility introduced by the coupling materially reduces the wear on the step-down gears. In order further to increase the advantages of the magnetic coupling, Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have developed a reversing coupling of this type, the use of which, by eliminating engine reversing, reduces both engine maintenance costs and the required capacity of the starting and reversing compressed-air plant. The non-reversing type of magnetic coupling normally consists of one member having a squirrel-cage winding and another fitted with salient poles. Electrically it is a matter of indifference whether the squirrel-cage member is connected to the engine or propeller-shaft, the arrangement adopted being purely a matter of mechanical convenience. In the arrangement of the reversing coupling to be described, a squirrel-cage rotor is connected to the propeller shaft, the outer member, which is connected to the engine shaft, consisting of a magnet wheel, as shown in Fig. 2, on page 306.

The operation of the coupling is similar to that of a three-phase induction motor, in which a rotating field is produced by the three-phase current in the stator winding, and the rotor rotates in the same direction as the field but at a lower speed, the difference being accounted for the slip. In the reversing coupling, when running in the ahead direction, the outer member is supplied with direct current, the rotating field being produced by the mechanical rotation of the member; the rotor follows this field, as in an induction motor. To make the coupling act as a reversing unit, it is necessary to reverse the direction of rotation of the field produced by the outer member without mechanically reversing its direction. This is attained by exciting the outer member by means of three-phase current, instead of direct-current, the connections being arranged so that the field produced rotates in the opposite direction from that of the engine.

The frequency of the three-phase current employed must be such that the reversed field produced rotates at twice the engine speed. This is necessary, since, mechanically, the outer member continues to rotate in the forward direction at engine speed. The reversed electrical field of twice the engine speed imposed on this motion then results in a reversed field of normal speed, so that the rotor and propeller run at normal speed but in a reversed direction. If, for instance, the outer member connected to the engine has 10 poles and is driven at 300 r.p.m., then, when it is excited by direct current, it will produce a 25-cycle forward rotating field. To generate a corresponding field in the reverse direction it is necessary to apply a 50-cycle exciting current. This will produce a 50-cycle rotating field in relation to the outer member, but owing to the forward rotation of this, the overall effect, in reference to the rotor, is a 25-cycle reversed field.

A simplified diagram of connections of the coupling is reproduced in Fig. 1, page 306. The squirrel-cage member, connected to the propeller shaft is indicated at *a*. The outer, engine, member carries a laminated core slotted for two star-connected three-phase windings *b* and *c*. Direct-current excitation is applied to winding *c*. It may be fed through two phases in series, the other being idle, or through two phases in series with the third, as shown in Fig. 1. Either arrangement produces alternate north and south poles. The alternator used to supply the excitation for reversed running is embodied in the coupling. It is indicated on the left of Fig. 1, and takes the form of a number of salient poles arranged on the outside of the engine member and indicated at *d* in the diagram. Outside these, and separated from them by an air gap, there is a three-phase stator *e*. When the coupling is running in reverse, the poles *d* are excited by direct current, the stator then producing a three-phase voltage which is used to excite the winding *b*. As the alternator current has to be double the frequency of that of the coupling, the number of poles of winding *d* is double that of winding *b*.

The method of control is simple. At starting, the engine is run up to a slow speed. Winding *e* is then excited by direct current and the propeller runs up to the speed of the engine. The engine speed is then raised to normal operating speed. For reversing, winding *c* is switched out and the engine speed reduced. The exciting winding *d* of the alternator is then supplied with direct current, winding *b* is excited, and the propeller reverses. The engine speed is then raised.

During forward running, winding *b* carries no current since winding *d* is not excited; there is also no voltage induced in it by winding *c*, since *b* and *c* are mounted on the same member. When running reversed, with winding *d* excited by direct current and winding *b* excited by alternating current from the stator, the rotating field in *b* induces a voltage in *c*. If windings *b* and *c* were wound with the same number of poles, this induced voltage might be considerably higher than the normal voltage. To prevent this effect, windings *b* and *c* are wound with, say, six and eight poles, respectively, so that they are mutually non-inductive.

The question of the rating of the alternator is of some interest. If it be assumed that the propeller is reversed when the ship is travelling at full speed ahead, then, as maximum reversing power is desirable, it may be assumed that the engine will be delivering full power for the speed at which it is running. The speed of the propeller under these conditions varies with the designed speed of the ship and propeller, but in an average case it will require full torque when it is revolving at half speed in the reversed direction. This corresponds to half power, so that if the engine is running at half speed, it will be carrying the full load corresponding to that speed. The electrical input to winding *b*, however, is equal to twice the propeller load, since the frequency is double. The alternator will accordingly be carrying full load, with the propeller absorbing only half load. As the engine output, neglecting losses, will equal the propeller load, this being the only outlet for power, the fact that the alternator is carrying full load indicates that there is an internal circulation of power. Half the electrical output from the alternator will be converted into mechanical power to drive the propeller and the other half will furnish mechanical power to drive the engine member of the coupling. This latter half assists the engine to provide full power to drive the alternator, and this state of affairs indicates that the alternator must be designed to give full power at half speed, so that its rating must be twice that of the engine. It may appear that this condition will demand an alternator of disproportionately large size, but actually, as full-torque reversal occupies only a brief period, a short-time rating for the alternator may be employed.

In this argument it has been assumed that the number of poles of winding *d* is twice that of winding *b*. Increased propeller torque may, however, be obtained by altering the ratio of the number of poles. If a ratio of 1·8 to 1 be used, instead of 2 to 1, and the propeller runs reversed at half speed; then, to develop full torque, the engine speed will require to be 62·5 per cent. of full speed, the alternator load will be 112·5 per cent. of full load, and the alternator rating will require to be 180 per cent. of the engine rating. With a pole ratio of 1·6 to 1, the engine speed is 85 per cent. and the alternator load 134 per cent., corresponding to a rating of 160 per cent. at full speed. Under neither of these conditions is the engine fully loaded. If with a ratio of 1·8 to 1 it is speeded up to 80 per cent., the propeller speed will be 64 per cent., with a torque of 125 per cent. This gives a load of 80 per cent., which is the full power of the engine at 80 per cent. speed. Under these conditions, the alternator load is 180 per cent. of full power, which is equivalent to 225 per cent. at full speed. With a pole ratio of 1·6 to 1, and the engine running at full speed, the propeller speed will be 60 per cent. and the engine power 72 per cent. of full power. The alternator load will be 190 per cent., and, as full speed is assumed, this will also be the rating. This ratio is not so advantageous as 1·8 to 1, as the propeller speed and torque are not so high.

These calculations are based on the reversal torque required while the ship is still moving at full speed ahead. As the ship loses way, the propeller torque for a given propeller speed will decrease. In the case of the 1·8 to 1 pole ratio, the engine speed at first is 80 per cent., at 80 per cent. load. As the ship slows down, the engine speed will rise and may reach full speed if the power absorbed by the propeller at its corresponding maximum speed does not exceed full power. For the case of the 1·8 to 1 ratio, the propeller speed corresponding to full speed of the engine is 80 per cent. It may be noted that the reversed coupling acts as a reduction gear. With a pole ratio of 1·8 to 1, the gear ratio is 1 to 0·8; with a pole ratio of 1·6 to 1, it is 1 to 0·6. The pole ratio of 2 to 1, as first described, gives a gear ratio of 1 to 1.

Mechanically, the coupling may take various forms. The arrangement of the alternator on the outside of the coupling proper, as already described, and as shown in Fig. 2, makes the most compact lay-out, but in some cases the relatively large external diameter may be an inconvenience. As an alternative, the alternator may be mounted on the engine shaft and the inner member of the coupling on the propeller shaft, with a bearing between the alternator and outer coupling member, as illustrated in Fig. 3. The whole arrangement may also be reversed, with the squirrel-cage member on the engine shaft. Although this reversing coupling may be looked upon as equivalent to a normal electric drive in which an alternator on the engine shaft supplies a motor on the propeller shaft, it has the advantage that as the alternator is seldom used, and is idle during ahead running, it can be rated on a short time basis and is consequently considerably smaller than is necessary for the usual electric drive. The efficiency during ahead running is also higher and the switchgear simpler.

REVERSIBLE MAGNETIC COUPLING.

MESSRS. THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

Fig. 1.

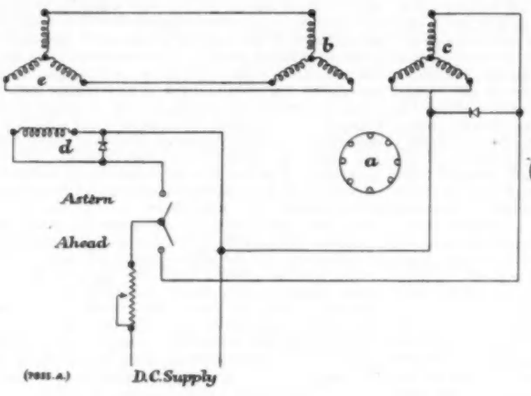


Fig. 2.

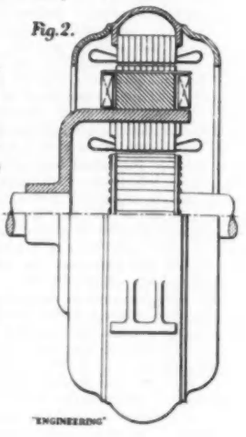
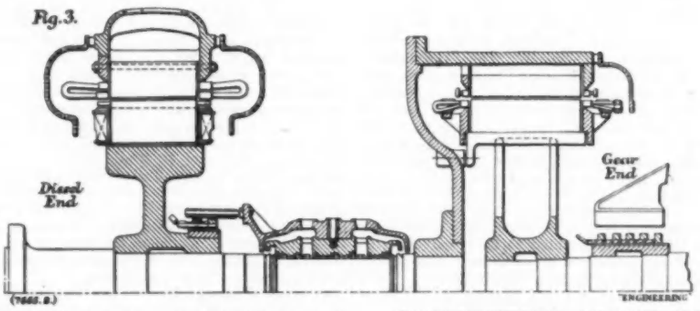


Fig. 3.



FAILURES OF SQUIRREL-CAGE ROTORS.

Although squirrel-cage rotors are generally regarded as of particularly robust construction, they are not immune from breakdown, a common fault being the cracking and fracture of the bars at the point where they join the end rings. Messrs. The Vulcan Boiler and General Insurance Company, Limited, Manchester, mention in the current issue of *Vulcan* an example of a squirrel-cage rotor failure resulting in considerable damage to the stator. The motor concerned was of 50 h.p., running at 900 r.p.m. on a three-phase 400-volt supply and driving a tube-reducing mill through gearing. A brake is fitted and starting is effected by means of an auto transformer. The breakdown took place without warning. On examination, the tubular conductors forming the windings were found to have broken away from the end rings in a number of places and where this had happened the current in the conductors passed through the core plates. This condition had given rise to arcing and burning so that the slots were enlarged to such an extent that the conductors lifted out of them by centrifugal force and rubbed against the stator. The contact twisted a stator core-end plate tooth, shorting two stator coils and rendering re-winding necessary. The rotor had to be re-built with new core laminations and conductors, the repair taking nearly six weeks to effect.

Breakdowns of this kind can be generally attributed to poor design or workmanship whereby indeterminate stresses are present in the joints. These stresses may be caused by the welding or brazing processes or by the end ring resonating to vibration. Another type of failure may result from the insulating sleeves fitted in the slots. If the sleeves char or deteriorate, movement of the conductors in the slots will take place with resulting wear followed by cracking and arcing.

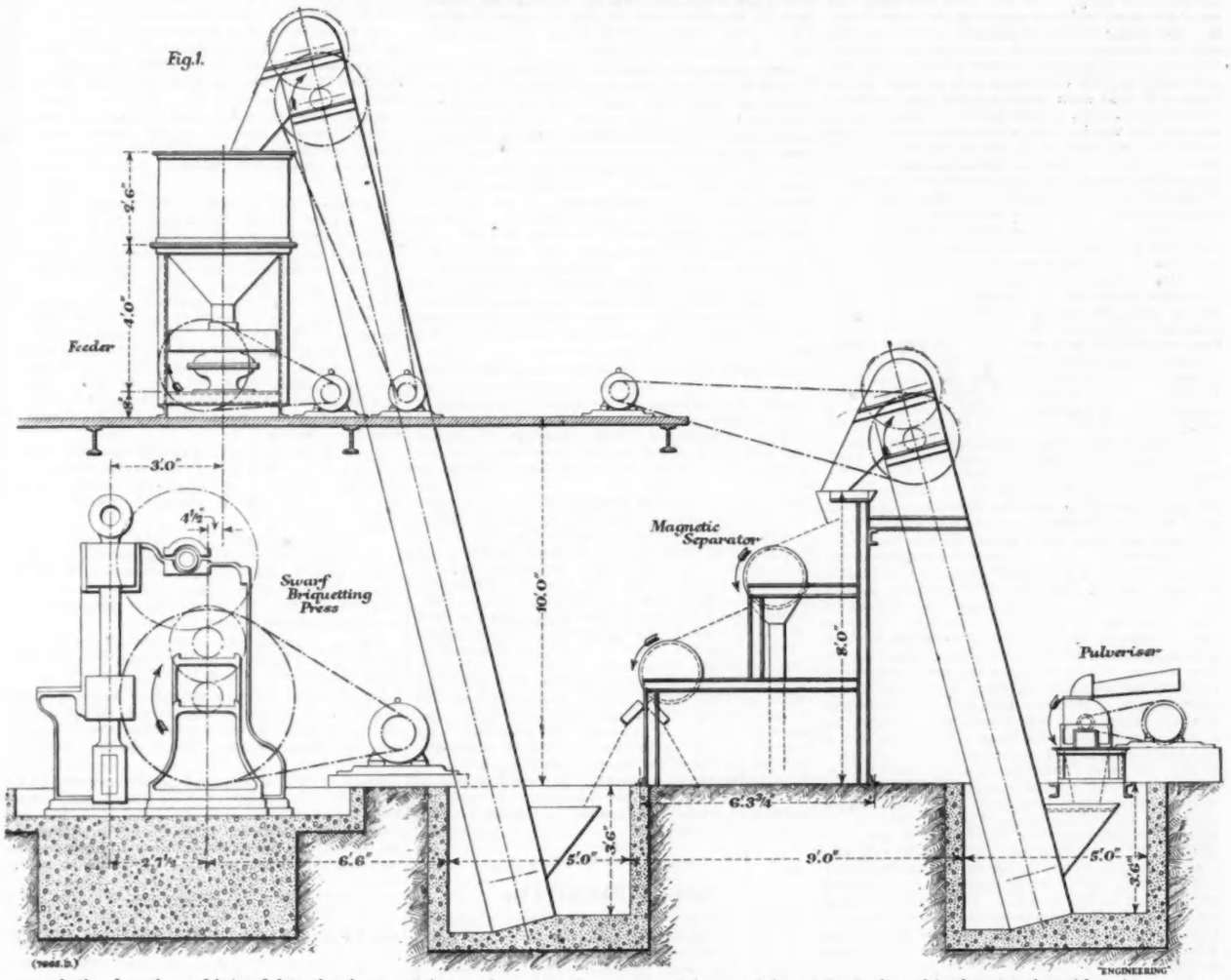
BRIQUETTING PLANT FOR METAL SWARF.

The utilisation of metal swarf by re-melting it in a cupola or other furnace, although a generally established practice has recently become of increased economic importance, owing to the modern practice of compressing the loose swarf into dense briquettes, which are not only easier to handle but also effect an improvement in cupola and other furnace operation. We propose to deal below with the swarf-briquetting plant as manufactured by Messrs. William Johnson and Sons (Leeds), Limited, Castleton Foundry, Armley, Leeds 12, representative machines being illustrated in Figs. 1 to 4, opposite, and on page 310. The particular plant illustrated in Fig. 1 is intended to briquette swarf of three different classes, viz., (1) light-alloy swarfs such as aluminium, Duralumin, magnesium, etc.; (2) heavy non-ferrous swarf such as gunmetal, phosphor-bronze, Delta metal and the like; and (3) cast iron. All these metals yield, in the main, swarf of a fragmental character which under suitable conditions of pressure can be compacted into briquettes without requiring any binding agent. The long helical swarf of steel, even when cut up by a chip-breaker, requires different handling and consideration of steel-swarf briquetting machines is, therefore, deferred for the time being.

It will be understood that since a plant capable of dealing with all three classes of swarf is somewhat elaborate, only firms that produce large quantities are likely to install one of this character. Concerns producing smaller quantities of swarf are, however, catered for by firms who purchase the swarf loose and briquette it in a central plant, re-melting it for subsequent sale, a briquetting industry having come into existence during recent years. The plant shown in Fig. 1, although suitable for all the three classes of material mentioned can, however, be modified. It is necessary in its entirety for the light-alloy swarfs. The swarf as collected from the machines is first passed through the pulveriser seen on the right of Fig. 1, and is reduced in it to the required grade, or uniform size, for briquetting. The reduced swarf is discharged into the boot of an elevator for transference to a magnetic separator. In some cases, however, it is necessary to remove cutting oils and compounds. This involves the delivery of the pulverised swarf into a basket, which is then immersed in a solvent solution and afterwards placed in a centrifuge in which the liquid is

BRIQUETTING PLANT FOR METAL SWARF.

MESSRS. WILLIAM JOHNSON AND SONS (LEEDS), LIMITED, LEEDS.



removed, the cleaned swarf being fed to the elevator for delivery to the magnetic separator. Alternatively, the pulverised swarf is delivered to a small rotary kiln where the cutting coils or compounds are evaporated. It is not yet established which of these two systems of cleaning is the more satisfactory.

The object of passing the non-ferrous swarf over the double-drum magnetic separator is, of course, to ensure the removal of any magnetic material present. The swarf is discharged from the magnetic separator into the boot of a second elevator and delivered to a service hopper above the feeder seen on the left of Fig. 1. The feeder has a rotary horizontal measuring table from which the swarf falls at a predetermined rate through a chute to the feed box of the briquetting press below it. The function of the hopper is, of course, to provide storage capacity, since the discharge from the pulveriser may be intermittent while the briquetting machine should be run as continuously as possible for economic reasons. The plant, as shown in Fig. 1, can be used equally well for heavy non-ferrous swarf or for cast iron, but where capital cost is a deciding factor and where the swarf is clean and of a grade of, say, below ¼ in., the pulveriser may be omitted. For the heavy non-ferrous swarf, however, the employment of a magnetic separator may be necessary. Clean cast-iron swarf of suitable grade may be fed directly, by hand or otherwise, into the hopper of the feeder.

The standard plant manufactured by Messrs. Johnson is capable of producing 8 cwt. to 12 cwt. of briquettes per hour from light-alloy swarf and from 10 cwt. to 20 cwt. per hour from heavy swarf. The power required for these outputs naturally varies but will be, roughly, as follows: pulveriser, 30 h.p. to 50 h.p.; elevators to magnetic separator and feeder hopper, 2 h.p. each; magnetic separator, 1 h.p. to 2 h.p.; measuring table, 1 h.p.; and briquetting press, 10 h.p. to 15 h.p. As regards the comparative bulk of the loose and briquetted swarf, with light alloys the ratio is 6 to 1, and with heavy swarf approximately 3 to 1. The density aimed at in producing the briquettes is, in most instances, from 70 per cent. to 75 per cent. of the solid metal. Since the process of swarf briquetting requires special plant involving the use of power and labour in excess of that employed when loose swarf is returned directly to, say, a cupola, the question naturally arises as to what advantages the process possesses. In the case of cast iron swarf, there are at least two advantages, the first of which is that of economy. On this head Mr. D. F. Galloway, in a paper entitled "Efficient Control and Disposal of Swarf and Scrap Metal," of which a summary was given in ENGINEERING, vol. 151, page 105 (1941), stated that by the employment of a well-arranged plant, cast-iron chips can be briquetted at a cost of less than 7*s.* per ton, and if the briquettes are used to form 10 per cent. to 20 per cent. of the cupola charge, it is possible to save up to 1*l.* per ton of melted iron. Messrs. Johnson give similar information in greater detail, the following being their figures for the production of one ton of melted iron. The cost when swarf is not added is given as 5*l.* 12*s.* 4*d.* per ton, this figure being arrived at by assuming 16 cwt. of pig-iron at 5*l.* a ton, and 4 cwt. of alloy iron at 7*l.* a ton, with an addition to cover a loss of 4 per cent. in melting. When briquettes are used the cost per ton is 4*l.* 10*s.*, a total made up by the cost of 16 cwt. of pig-iron at 5*l.* a ton, and 4 cwt. of cast-iron swarf valued at 20*s.* per ton, plus cost of briquetting, with the same addition as above for melting losses.

The second of the advantages mentioned above as resulting from the use of cast iron briquettes is a reduction in the melting loss, together with an improvement in the physical properties of the finished product. On the first head we understand that systematic research, in conjunction with practical experiment on a commercial scale, has demonstrated that cast-iron briquettes show a loss of not more than 5 per cent. to 10 per cent. when melted alone and of only about 3 per cent. to 4 per cent. when melted with pig-iron in the usual proportions of 80 of pig to 20 of swarf. The improvement in the finished product appears to be an established fact, though the reason for this is a little obscure. The explanation generally given is that the relatively loose structure of a briquette permits the oxidation of carbon at an early stage and though the major part of this loss is replaced on fusion, all of it is not restored. The net result would thus appear to be that there is an appreciable reduction of the carbon in the melt. Messrs. Johnson mention the experience of a foundry producing castings of very high grade for the cylinders of internal-combustion engines, etc., this firm reporting that cast-iron briquettes give the same results as steel scrap and can replace an equal weight of high grade irons. If the theory just referred to is accepted, a logical inference might be that cast-iron swarf fed to the cupola in a loose condition would be even more effective. This, however, is not the case, the loss of carbon, *i.e.*, the oxidation, being too complete. There are also positive losses of material due to the air blast, and this loss may be as high as 50 per cent. The alternative method of charging the cupola with containers holding the loose swarf, although effective in reducing both oxidation and blast losses, does not do so to a sufficient extent to offset the cost of the containers and of the labour employed in packing them. Briquetting therefore seems to be the best method of swarf disposal.

Some particulars of the units comprising the plant shown in Fig. 1 may now be given. The pulveriser seen to the right in this figure is illustrated by the photograph reproduced in Fig. 4, on page 310. It consists of a high-speed mill having a rotor enclosed in cast iron and steel casings, which are provided with renewable liners. An adjustable breaker plate is carried on the upper casing, the lower casing being furnished with a screen-bar grid with the bars spaced to suit the size of product required. The rotor carries pivoted hammers which, though held sufficiently rigid by centrifugal force to break up the swarf, will yield when meeting tramp iron or similar recistant substances. Each hammer is double-ended and has four wearing faces which can be used in turn as they become worn to the limit of usefulness. The effect of wear of the faces up to this limit is to coarsen the product, this tendency being countered by adjusting the breaker plate so as to be closer to the hammers; a consistent fineness of product throughout the life of the hammers is obtained in this way. The swarf, which may be in the form of bushy turnings, is fed into the pulveriser through an opening directly above the rotors. It is thus immediately engaged by the hammers and the longer pieces receive a primary reduction on the breaker plate, the roughly-sized fragments and smaller unbroken pieces then being swept round to undergo a final reduction on the screen bars. The correctly-sized material escapes through the grid while the oversize fragments are carried round for further reduction. Tramp iron, etc., is automatically deposited in a catcher at the back of the machine from which it can be removed while the rotor is running. The rotor shaft is mounted in grease-lubricated ball bearings and carries either a flat belt or Vee-rope pulley, or, alternatively, a Wellman-Bubby coupling, for direct drive.

The elevator which delivers the pulverised swarf to the feed hopper of the magnetic separator is of normal type. The hopper discharges on to a vibrating tray of mild steel and brass, which shakes the swarf on to the front upper quadrant of a high-intensity magnetic drum, 30 in. in width. The magnetic separator is illustrated in Figs. 2 and 3, page 310. The magnetic units of the drum are designed so that when non-ferrous swarf is being handled any particle of iron present is turned over in order to shake off the adherent swarf which is to be passed on to the second drum. This material falls on to a second vibrating tray, whence it passes to the second drum, which is provided with a different type of magnetic unit since the percentage of iron to be dealt with is now small and the separating action must be more searching. Each drum has a separating efficiency of approximately 97 per cent., so that the swarf discharged from the second drum is virtually iron-free when it is delivered to the boot of the elevator which takes it up to the feed hopper above the briquetting press. The iron swarf is, of course, collected separately for addition to the swarf used for cast-iron briquettes. The magnetic separator is a self-contained unit, having its own driving motor and generating set for magnetic excitation. All shafts are mounted in ball bearings. The elevator, storage hopper and rotary measuring table are of normal type and need no description, but we proposed to describe the swarf-briquetting machine in a subsequent article.

(To be continued.)

Federation of Manufacturers of Contractors' Plant.—We are informed that manufacturers of contractors' plant have formed a body, known as The Federation of Manufacturers of Contractors' Plant, for the purpose of representing their common interests during and after the war. Information can be obtained from the secretaries of the Federation, Messrs. Binder, Hamlyn and Company, River Plate House, 12 and 13, Southplace, London, E.C.2.

The Fuel Luncheon Club.—The next meeting of the members of the Fuel Luncheon Club will be held at the Connaught Rooms, Great Queen-street, Kingsway, London, W.C.2, on Wednesday, October 22, at 12.40 for 1.10 p.m., when Lt.-Col. W. A. Bristow, M.I.E.E., will install Sir David Milne-Watson, Bart., LL.D., as President of the Club for the coming year. After installation, Sir David will deliver his presidential address, entitled "Fuel and the Future."

Control of Rates for Hire of Plant.—The Ministry of Works and Buildings wishes to draw attention to the recently published Order on the Control of Rates of Hire of Plant (S.R. & O., 1941, No. 1277). This Order gives a list of maximum rates at which various types of building and civil-engineering contractors' plant can be let out on hire, together with the conditions. It is emphasised that these rates apply not only to plant hired for Government work but also to plant hired for private work, and that, while the Order is in force, it is illegal to exceed these rates in any circumstances. Copies of the Order may be purchased, price 2*d.* net, from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Lead Pipes.—A revision of specification No. 603, relating to lead pipes of the B.N.F. ternary alloy No. 2, has recently been published. This specification was first issued in May, 1935, but as a result of experience gained in its use, it was found that certain modifications were desirable and these have now been included. The main points in the revision are that the chemical composition and method of marking are given in greater detail. Thus, it is specified that the tin shall be not less than 1·25 per cent. or more than 1·75 per cent., and the cadmium not less than 0·2 per cent. or more than 0·3 per cent., the lead constituting the remainder of the alloy. Furthermore an additional clause has been included with regard to grain size, and the ranges of pressure for which the various weights of pipe may be used have been modified. Restrictions are also placed on the pressure in pipes used for hot water.

Symbols for Diagrams of Chemical Plant.—In October, 1938, the Chemical Engineering Industry Committee appointed a small exploratory committee consisting of representatives of the Institution of Chemical Engineers, the Society of Chemical Industry, the British Chemical Plant Manufacturers' Association, and the Association of British Chemical Manufacturers, to review proposals which had been received from the International Standards Association for the adoption of symbols for chemical plant, and to consider whether it would be of advantage to industry to issue British Standard symbols to be used in diagrams relating to such plant. The exploratory committee reported unanimously in favour of such a set of symbols and, as a result, the Chemical Engineering Industry Committee appointed a representative committee to draw up a specification. This specification, which is entitled "British Standard Symbols for Use on Diagrams of Chemical Plant," has now been issued as No. 974-1941. In their selection of symbols the committee proceeded on the principle that, in order to maintain the number of basic symbols at a minimum, only those most necessary should be adopted. Furthermore, the symbols should be, as far as possible, sufficiently pictorial to enable the units of plant represented by them to be readily recognised. It should be pointed out that the committee has endeavoured to avoid the use of any symbol which might be identified with a proprietary article.

BOOKS RECEIVED.

University of Michigan. Official Publication. *Proceedings of the Twenty-Seventh Annual Highway Conference. Held at the University of Michigan, February 19 to 21, 1941.* Ann Arbor, Michigan, U.S.A.: University of Michigan.

United States Bureau of Mines. Miners' Circular No. 42. *Barricading as a Life-Saving Measure in Connection with Mine Fires and Explosions.* By D. Harrington and W. J. Fene. Washington: Superintendent of Documents. [Price 10 cents.]

United States Bureau of Mines. Bulletin No. 437. *Coal Mine Accidents in the United States in 1938.* By W. W. Adams, L. E. Geyer and M. G. Parry. Washington: Superintendent of Documents. [Price 15 cents.]

Design of Modern Steel Structures. By Dr. L. E. Grinter. New York: The Macmillan Company. [Price 5 dols.] London: Macmillan and Company, Limited.

Department of Scientific and Industrial Research. Wartime Building Bulletin No. 15A. (Supplement to Bulletin No. 15.) *Standard Designs for Single-Storey Factories for War Industries.* London: H.M. Stationery Office. [Price 6*d.* net.]

United States Geological Survey. Water-Supply Paper No. 878. *Surface Water Supply of the United States, 1939. Part 8. Western Gulf of Mexico Basins.* Washington: Superintendent of Documents. [Price 40 cents.]

United States Bureau of Mines. Bulletin No. 438. *Quarry Accidents in the United States during the Calendar Year 1939.* By W. W. Adams and Virginia E. Wrenn. Washington: Superintendent of Documents. [Price 10 cents.]

United States Bureau of Mines. Technical Paper No. 621. *Carbonising Properties and Petrographic Composition of Upper Freeport Coal from Morgantown District, Monongalia County, W. Va., and of Lower Freeport Coal from Eastern Indiana County near Cambria County, Pa.* By A. C. Fieldner and others. Washington: Superintendent of Documents. [Price 15 cents.]

PERSONAL.

Captain A. H. Read, chairman of the British Iron and Steel Corporation (Scrap), Limited, has been appointed a member of the Salvage and Recovery Board, Ministry of Supply, which, as stated on page 288, *ante*, is presided over by Sir A. Vyvyan Board, D.S.O., M.C.

Sir David Ross, K.B.E., Provost of Oriel College, has been elected Vice-Chancellor of Oxford University in succession to Professor G. S. Gordon, President of Magdalen College, who has held the position for three years.

Mr. L. Pyke has been made a director of Messrs. Romilly Motor Company, Limited, Romilly Crescent, Cardiff, distributors for South Wales of Messrs. The Associated Equipment Company, Limited, Southall, Middlesex.

Consequent upon the death of Mr. George Balfour, M.P., Major Harry Richardson, M.C., F.R.S.E., M.I.E.E., J.P., has been elected chairman and managing director of the Metropolitan Electric Supply Company; Mr. William Shearer chairman of the Midland Counties Electric Supply Company; and Colonel Sir Joseph Nall, D.S.O., D.L., M.P., chairman of the Lancashire Electric Light and Power Company. Mr. W. Shearer has been appointed a director of the last-named company.

Mr. J. R. Harrison has been appointed service engineer of Messrs. The Associated Equipment Company, Limited, Southall, Middlesex, for the North-Western Area, comprising Lancashire and Cumberland and a portion of Cheshire. His address is 107, Framlingham-road, Sale, Cheshire.

Mr. F. Stirling Coates, who was appointed district manager for the Yorkshire Electric Power Company at Leeds in May, 1939, has been made assistant to the manager of the Central Electricity Board (Central England Area).

Mr. Thomas McGreevy, B.Sc., who has been assistant in the department of electrical engineering and mathematics of the Technical College, Bell-street, Dundee, for the past four years, has been appointed head of the electrical section of the engineering department of the Municipal Technical College, Oldham.

Messrs. Watsons (Metallurgists), Limited, have removed to Pulvometal Works, Mill-lane, Dronfield, near Sheffield (telephone: Dronfield 2136).

Mr. Harold Heath, a director of Messrs. Commer Cars, Limited, Karrier Motors, Limited, and other companies, has been appointed director of the aero-engine factories connected with Messrs. Rootes Securities, Limited.

Mr. E. S. Cox, personal and technical assistant to the chief mechanical engineer, London Midland and Scottish Railway, Derby, has been appointed chief technical assistant to the latter. Mr. G. F. Kent, assistant to the district engineer of the company at Inverness, has been made assistant to the district engineer at St. Pancras.

NOTES FROM THE SOUTH-WEST.

Cardiff, Wednesday.

The Welsh Coal Trade.—Considerable interest was shown in the Welsh steam-coal trade during the past week on the approaching termination of the 1937 Conciliation Board Agreement which was in force for four years. The matter has been under discussion by the Executive Council of the South Wales Miners' Federation. The agreement was of the most comprehensive character and besides giving wage advances all round it introduced extensive changes in the basis of payment. Under present circumstances it was not expected that any fundamental changes would be permitted in district agreements, and it was therefore considered likely that the existing agreement, with certain probable amendments on minor points, would be extended for another year. New business continued to come in briskly on the market, but in view of the heavy commitments of most producers, salesmen could accept but little new business for early delivery. Current productions were almost entirely reserved for deliveries under standing contracts and stem lists were well filled for some time to come. The general tone was consequently very firm. Best large descriptions were available in small quantities, but a good demand was experienced for the sized kinds which, however, were almost completely sold for some time to come. The strongest feature was presented by the bituminous small grades which were in keen request but scarce, and the occasional parcels that became available were readily taken up at high figures. Some of the inferior dry steam smalls were offering freely and were dull.

The Iron and Steel Trade.—Activities in the iron and steel and allied trades were well maintained during the past week. Tin-plates were in steady demand from inland users and the bulk of the present restricted output was almost entirely absorbed in this direction. Galvanised and other sheets were less active.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Increased outputs are reported in many types of products, particularly those required by firms turning out equipment for the Forces. Commercial business is at a satisfactory level, and export orders are fairly numerous. There is an abnormal demand for basic steels. The melting plant, which has been greatly extended since the beginning of the war, is operating at full capacity. Business is also brisk in acid steel and similar materials. Little difficulty is experienced in getting adequate deliveries of hematites and pig iron. The scrap position is satisfactory. Makers of high-efficiency steels are busy, and new melting plant is being installed. Stainless, heat- and acid-resisting and abrasion-resisting, and other special steels are in exceptionally strong demand, and tool steel is active. The heavy machinery and engineering branches are busy. Business in steelworks' and ironworks' machinery and related equipment continues to increase. Heavy forging and bending presses are on order for customers in the North of England. Boiler makers are working at full capacity, and business in electrical plant, grinding and crushing equipment, and mining plant is increasing. The demand for agricultural-machinery parts and implements has been well maintained, and producing firms are busily employed preparing for the coming season. Inland needs are substantial, and the calls from the Colonies and Dominions are encouraging. The tool-making branches are busily employed.

South Yorkshire Coal Trade.—More orders are circulating for coal. Industrial fuel is in strong demand; iron- and steelworks, in particular, are taking larger supplies. Railway companies are buying locomotive coal freely and steam coals are active. Smalls and slacks are in stronger demand, and the house coal market is firmer. All types of cokes are in request. The export position generally shows little change, business being very restricted.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little change in the conditions of the Scottish steel trade. The output of ship plates, sections, etc., is being maintained at a high level and the demand for boiler plates is very strong. Special high-grade steels are in increasing demand and the steelmakers are meeting the requirements of their clients satisfactorily. The lighter grades of steel material are extremely active. The makers of black-steel sheets have well-filled order books, the demand for the thinner qualities tending to increase. The steel scrap position is practically unchanged. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—A steady business is reported in the West of Scotland malleable-iron trade and although orders have increased recently a further improvement would be welcomed. Deliveries of the necessary scrap are somewhat slow. The position of the re-rollers of steel bars shows little change and although they have a fair amount of work booked they are still able to promise early delivery of any urgent business offered. Stocks of semies are ample for present and immediate future requirements. To-day's prices are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Active conditions still prevail in the Scottish pig-iron trade and the current large output is quickly absorbed. The demands of consumers continue on a large scale and the requests for deliveries of hematite and basic iron are pressing. Foundry iron is rather slow. The following are to-day's market quotations:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

THE BRITISH ENGINEERS' ASSOCIATION.—At a meeting of the Council of the British Engineers' Association following the 29th annual ordinary general meeting, held on October 9 in London, Mr. Joseph James Carter, managing director of Messrs. Crossley Brothers, Limited, and chairman of Messrs. Crossley-Premier Engines, Limited, was unanimously re-elected President of the Association for the third successive year. By a resolution of the Council, Mr. Cecil Bentham, chairman of Messrs. Henry Simon, Limited, was elected a vice-president. Mr. A. Vines, M.A., Mr. E. Bruce Ball, Mr. J. Maughfling, and Major C. P. Napier Raikes, M.C., were also re-elected vice-presidents.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Nearly all kinds of raw materials are plentiful and, despite the stoppage of supplies from America, stocks of semi-finished commodities remain at a high level, and the outputs of finished iron and steel cover the actual requirements for work of national importance. Conditions, however, necessitate the drastic restriction of tonnage distribution for ordinary industrial purposes and commercial business has diminished correspondingly. Delivery licences are issued fairly freely to meet the rising demand, and substantial sales have been made for supply over periods to the end of the year. Priority users of iron and steel are obtaining full supplies without undue delay.

Cleveland Iron Trade.—Foundry pig iron allocations are ample but there is no indication of an improvement in the supply of local brands. Deliveries from the Midlands and other producing centres, however, are sufficient to enable stocks to be replenished. The bulk of the business passing is carried on directly between producers and users, but merchants are gradually handling an increasing tonnage. The recognised market values of Cleveland pig remain at the level of No. 3 quality at 128*s.* delivered within the Tees-side zone and, under existing conditions makers see no necessity for an increase in production.

Basic Iron.—The heavy output of basic iron provides no tonnage for the market but is adequate for the heavy requirements of the makers' own steelworks and to enable additions to be made to the quantities stored for emergencies. The fixed price of basic iron remains at 120*s.* 6*d.*

Hematite.—The shortage of hematite is rather less acute than it has been, but the control still exercises a close watch on distribution, and consumers are able to obtain delivery licences only when no other iron can be used for the work in hand. Conditions still preclude any increase in production but the increasing use of refined iron, in place of hematite, is gradually relieving the stringent position. Official hematite quotations are ruled by No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England areas.

Foreign Ore.—A good deal of foreign ore is stored at consumers' works and imports of most descriptions are being continued regularly, but hematite qualities are still difficult to obtain.

Blast-Furnace Coke.—The stabilised prices of Durham blast-furnace coke are firm at the equivalent of good medium qualities at 36*s.* 9*d.* f.o.r., but transactions are few.

Manufactured Iron and Steel.—The consumption of semi-finished iron and steel is exceptionally heavy and imports have practically ceased, but tonnage accumulations at the re-rolling mills are large and stocks are likely to be kept at a satisfactory level by increased deliveries of local products. Finished-iron firms are actively employed on heavy work but could handle more orders for light commodities. Structural material is in only moderate request but the demand for other descriptions of steel is keeping the plants operating at full capacity. There is no reduction in the demand for ship, tank and boiler plates, black and galvanised sheets and railway requisites, while the call for special alloy steels will necessitate a further increase in production.

Scrap.—Users of heavy iron and steel scrap are ready to negotiate for further supplies though they have recently arranged substantial contracts, but consumers of light material have covered their requirements well ahead.

UNITED STATES COLLIERY INDUSTRY.—The average production of bituminous coal in the United States during the week ending September 27 was 1,783,000 tons daily, against 1,655,000 tons in the preceding week and 1,692,000 tons in the corresponding week of 1940.

TREFOREST SCHOOL OF MINES.—The Calendar of the School of Mines and Technology, Treforest, Glamorganshire, for the session 1941-42, has recently come to hand. It contains particulars regarding the full-time, part-time day, and evening courses available in various engineering and scientific subjects. Day students are prepared for the examinations for the joint diploma in mining and for the B.Sc. (Engineering) degree of London University. Full-time courses are also held in civil, structural and chemical engineering, surveying, and other subjects. Part-time day courses are available for colliery managers, under-managers and surveyors and for engineering apprentices, while evening courses in engineering, handicrafts and scientific and commercial subjects are provided for colliery employees and other workers, and for apprentices. The calendar contains detailed time tables, syllabuses and examination regulations, and particulars regarding fees, scholarships, prizes and other matters of interest to intending students.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Literary and Philosophical Society's Rooms, Newcastle-upon-Tyne. Annual General Meeting. Presidential Address, by Mr. W. A. Woodeson. *Student Section:* Thursday, October 23, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. Address by the Chairman of the Student Section, Mr. George Wright, Junr., on "Some Aspects of Cylinder Head and Combustion-Chamber Design for Internal-Combustion and Compression-Ignition Engines."

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Centre:* Saturday, October 18, 2.30 p.m., The Hotel Metropole, King-street, Leeds. Address by the Chairman of the Centre, Mr. F. Gurney. *Institution:* Thursday, October 23, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. Presidential Address by Sir Noel Ashbridge. *South Midland Centre:* Saturday, October 25, 1 p.m., The Grand Hotel, Birmingham. Lunch. Inaugural Address by the Chairman of the Centre, Mr. R. H. Rawll. *North Midland Students' Section:* Saturday, October 25, 2.30 p.m., The Hotel Metropole, King-street, Leeds. Inaugural Address by the Chairman of the Section, Mr. A. E. Cunningham, on "Electric Motors."

INSTITUTE OF METALS.—*Birmingham Local Section:* Saturday, October 18, 2.30 p.m., The James Watt Memorial Institute, Birmingham. "The Welding of Light Alloys," by Dr. E. G. West.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Yorkshire Branch:* Saturday, October 18, 2.30 p.m., The Hotel Metropole, Leeds. Address by the Chairman, Mr. H. A. Whitaker.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, October 18, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Fire Fighting and the Engineer," by Mr. J. W. Stenson.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Saturday, October 18, 6 p.m., at Messrs. Robert Hyde and Son, Limited, Stoke-on-Trent. "Some Recent Researches in Welding," by Professor F. C. Lea.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, October 21, 6.30 p.m., Sheffield Metallurgical Club, 198, West-street, Sheffield, 1. An informal discussion of matters of general interest.

INSTITUTE OF WELDING.—*North-Eastern (Tyneside) Branch:* Thursday, October 23, 7 p.m., The Mining Institute, Neville-street, Newcastle-upon-Tyne. General Meeting. Chairman's Address and Display of Films.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 24, 2.30 p.m., Storey's Gate, St. James's Park, Westminster, S.W.1. General Meeting. Presidential Address, "The Position of the Locomotive in Mechanical Engineering," by Mr. W. A. Stanier. (*See also page* 313).

INSTITUTION OF CHEMICAL ENGINEERS.—Friday, October 24, 2.30 p.m., The Institution of Civil Engineers, Great George-street, Westminster, S.W.1. The Fourth Hinchley Memorial Lecture: "Scientific Knowledge and Action," by Sir Richard A. Gregory, Bart.

INSTITUTE OF TRANSPORT.—*Metropolitan Graduate and Student Society:* Saturday, October 25, 2.15 p.m., The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Address by the President of the Institute, Mr. J. S. Nicholl.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Saturday, October 25, 2.30 p.m., St. Bride Institute, Bride-lane, Fleet-street, E.C.4. "Current Events Have Cast Their Shadows," by Mr. A. E. Penn.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, October 25, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Economic Planning of a Modern Store," by Mr. J. S. Beaumont.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—At the annual general meeting of the North-East Coast Institution of Engineers and Shipbuilders, which is to be held at Newcastle-upon-Tyne to-day, Friday, October 17, at 6 p.m., the report of the Council is to be submitted and an address will be delivered by the President, Mr. W. A. Woodeson. The Institution Scholarship will be presented to Mr. Harold Greenhow, the Institution Bursary of 50*l.* to Mr. Ivo Harold Axbey, and the Institution Prize of 5*l.* to Mr. William Geoffrey Geddes. The presentation of awards for papers read before the Student Section during the 1940-41 session will also be made. The recipients comprise Messrs. T. Corin, B.Sc., R. Coats, E. Panagopoulos, B.Sc., W. G. Brown, A. Gilchrist, B.Sc., W. T. Atkinson and George Wright, Junr. The Tenth Andrew Laing Lecture will be delivered on Friday, October 31, at 6 p.m., at the Mining Institute, Newcastle-upon-Tyne, by Sir Westcott S. Abell, K.B.E. His subject will be "Merchant Sea-Power, 1919-1939."

BRIQUETTING PLANT FOR METAL SWARF.

MESSRS. WILLIAM JOHNSON AND SONS (LEEDS), LIMITED, LEEDS.

(*For Description, see page* 306.)

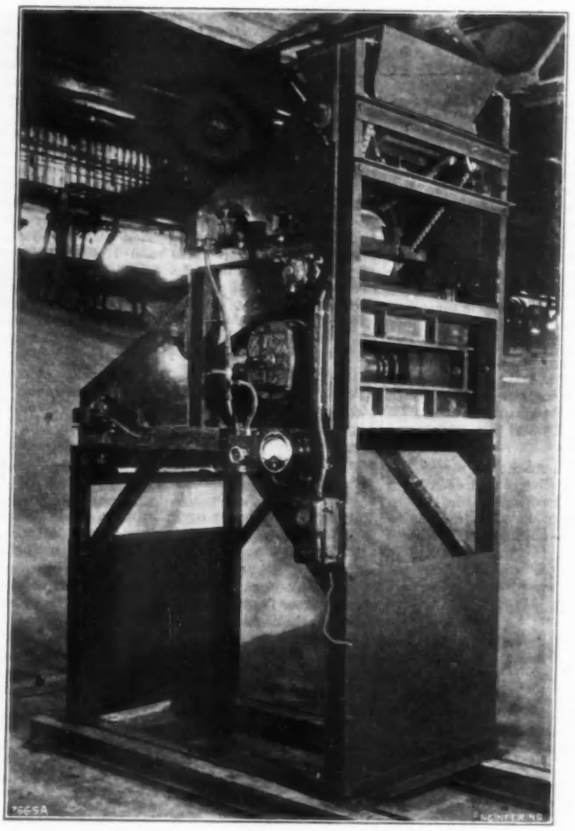


Fig. 2. Rear View of Magnetic Separator.

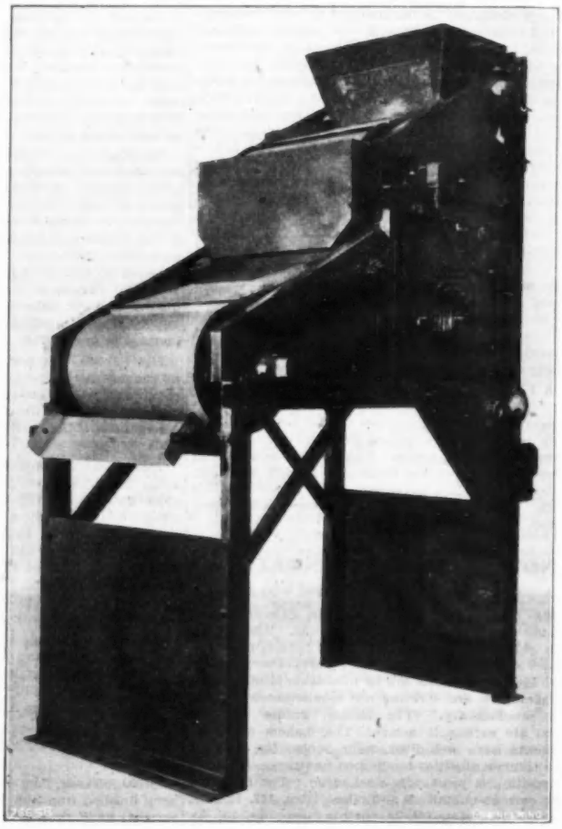


Fig. 3. Front View of Magnetic Separator.

University College Engineering Society.—The recently-published 1940-41 issue of the *Journal* of the Engineering Society of University College, Gower-street, London, W.C.1, contains a number of technical articles in addition to accounts of student activities and college news. The articles include one by Mr. H. H. Rosenbrock on "Mechanical Analogies of an Electrical Circuit"; and others by Mr. W. B. H. Bolt on "Training the Engineer to Meet Modern Requirements," by Mr. M. K. Oke on "Practical Fuel-Injection Systems," by Mr. R. T. Gill on "Circuit Breakers," and by Professor R. O. Kapp on "Laws and Order in Physics."

The Rubber-Bonding Industry.—It has recently been announced that a company named Rubber Bonders, Limited, Flexilant Works, Dunstable, has been formed to continue the combined work hitherto carried out by the Dynaflex Division of the Manganese Bronze and Brass Company, Limited, and the Empire Rubber Company, the Dynaflex Division having commenced working some years ago under the patents of Messrs. S. A. Paulstra, whose trade mark is "Dynaflex." The Manganese Bronze and Brass Company manufacture all kinds of non-ferrous metal alloys, make marine propellers, and carry out electroplating and marine-engineering work. The Empire Rubber Company are specialists in rubber moulding. The rapid development of rubber bonding has rendered the formation of a separate company essential and Messrs. Rubber Bonders, Limited, have been granted the trade mark Flexilant, to replace the names hitherto used, of which Dynaflex was one. The products of the new company include flexible mountings for all types of plant capable of carrying loads in excess of 5 tons per mounting, and flexible couplings, for conditions of torsional vibration, transmitting up to 3,000 h.p., running at 2,000 r.p.m., weighing a quarter of a ton and measuring 21 in. in diameter. Components of extreme delicacy, including the suspensions and insulation of milli-voltmeters, will also be produced.

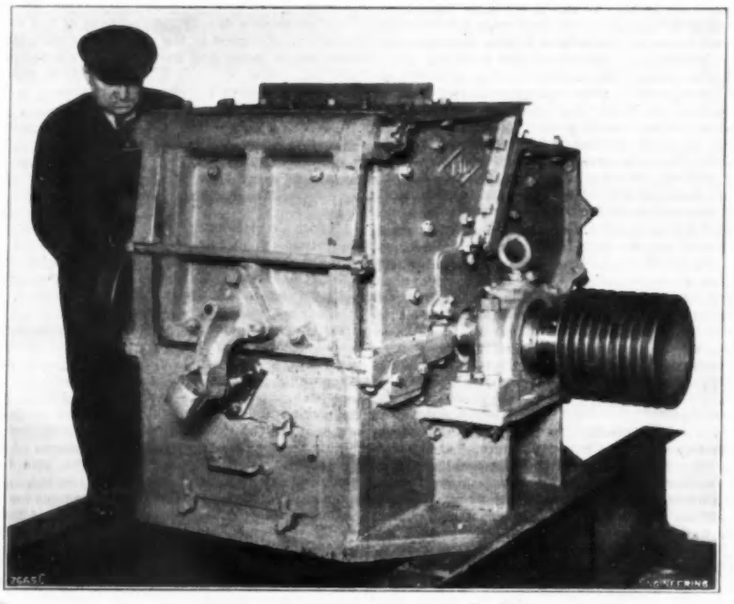


Fig. 4. Rotary Pulverising Mill.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEGRAPHIC ADDRESS } "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, OCTOBER 17, 1941.

VOL. 152. No. 3953.

PLANNING.

THE use of the word "planning" as a verbal substantive appears to date from very recent times. It is not given in *The Shorter Oxford English Dictionary*. The particular meaning it has now assumed, however, is likely to endure for many years in the vocabulary of those who make it their business to instruct mankind in the conduct of his affairs, and it must be accepted in any consideration of administrative activities. Clearly, those who make most use of the word are consciously or subconsciously aware of the fact that it is modern, and in their traffic with it usually imply that it is a new thing which carries within itself the talisman of future progress. To plan is "to form a draught of any intended work; to scheme or to devise." The simple-minded might have supposed that Noah did a little of this kind of thing before he started the construction of the Ark, and that the London and South Western Railway did not undertake the modernisation of Southampton Docks without preliminary planning. The modern enthusiasts for the process, however, imply that these earlier works were carried out without the benefits of the new method which they have discovered.

The present epidemic of planners probably originated in the town planning of which so much has been heard in the last twenty years. About the value of co-ordinated activity in this particular aspect of public affairs there is not likely to be much difference of opinion in general terms, although the details of a plan in any particular case may well result in acute controversy. In the past, the form and extension of towns was considered to be a purely local matter, if it was considered at all, with the result that road lay-outs were adopted which ill served the interests of contiguous districts, or the country as a whole. Apart from æsthetic considerations, which now receive more attention than they did at one time, the realisation of the unsatisfactory nature of this state of affairs has probably been due to modern traffic developments. A village situated on an arterial road has ceased to be a self-contained entity and the arrangement of its roads has become a matter of common concern. Hence it has been considered desirable that town planning should deal with larger areas, which in some aspects of the matter may be nation-wide. This has necessarily led to greater centralisation of authority.

Town planning in its broadest aspect ultimately leads to some type of control which will be exercised over the whole country and will directly, or indirectly, determine the width and site of every new road that is made, or old one that is reconstructed. We have already advanced some way towards this state of affairs and the message of the planners appears to be that we should do the same thing in many other branches of activity. This was illustrated by various communications read at the recent British Association conference on Science and World Order. Some attention was given to questions of power supply. Sir Harold Hartley, for instance, referring to the conservation of fuel resources, said that in advanced countries maximum economy might be attained by regional planning which would permit the development of combined heat and power plants, the use of extraction steam for heating eliminating the usual condensation losses. Another aspect of the power problem on which he touched was the development of the more backward countries. Their first need, he said, was cheap transport; this is closely related to questions of fuel supply and conservation.

Sir Harold Hartley, unlike some publicists, did not assume that nothing had been done. He talked of the replanning of the world, not its planning. In electric-power supply, which was an important aspect of his subject, much centralisation of control has already taken place in this country, and, indeed, in many other countries. Generation and main transmission are here in the hands of the Central Electricity Board, and proposals were far advanced, before the outbreak of war, for the extension of their control to distribution. No doubt much will again be heard of this in due course. The operation of combined heat and power stations on a large scale, however, would represent an extension of public or semi-public control to a degree considerably beyond that which we have yet reached. It would mark an important step forward in that socialisation of industry which the planners are, in effect, advocating. They do not usually put it that way and in general assert that what they are contending for is a more intense application of scientific knowledge to public problems. The methods they propose for securing this are, however socialistic. They are not necessarily to be condemned on that ground, but it will clear the air of what Sir Harold called "picturesque phrases without quantitative consideration" if it is recognised that most of the planning talk is concerned with administrative method and not with the application of science to industry.

Governments and industry have always used all the science they could get, sometimes ineffectively owing to bad technical advice or the ignoring of good technical advice, but the idea that it is only here and now that mankind is to begin to apply scientific advance in practice is baseless. When the Emperor Justinian, in A.D. 533, assembled a fleet of five hundred transports at Constantinople for the invasion of North Africa, he did not ignore what the science of that time had made possible. Incidentally, he also did a considerable amount of preliminary planning. The only way in which the position to-day differs from that of the past is that the general spread of scientific knowledge—or perhaps scientific notions would be a better expression—has created a public realisation of the fact that scientific matters can be handled properly only by people with scientific training and that administrators, if they are to make the best of scientific possibilities, must consult those who can speak with authority in the particular sphere concerned.

The fact that planning is essentially a matter of administration and not of science is well illustrated by the references to the development of transport in backward countries which were made at the conference. Dr. Othmar Ziegler, in the course of a plea for the construction of an adequate transport system in Southern Europe, illustrated the prevailing standard of living in that part of the world, by stating that while there was one motor car to 21 inhabitants in the United Kingdom, there was but one for 119 in Czechoslovakia, one for 147 in Austria, 504 in Hungary, 797 in Rumania, 1,172 in Jugoslavia, and 1,344 in Bulgaria. His

point was that these countries had great resources and that the social condition represented by these motor-car figures could be enormously improved by the construction of rail and road systems. Similarly, Sir Harold Hartley said that the first need of the backward countries was "cheap transport adapted to the needs and energy resources of the particular region." These statements may well be accepted, but they have nothing directly to do with the progress of applied science. The work of engineers and physicists will continue to improve traction methods whether the planners construct more roads and railways in Jugoslavia or whether they do not. The only bearing which scientific advance has on the matter is that, as it devises new and improved methods, it may so reduce the cost of installing and operating transport systems that it will become economically possible to build roads and railways in countries in which immediate, or proximate, traffics are insufficient to cover the costs.

There is nothing new in the construction of roads and railways in new countries with the idea of developing their resources; it is an every-day problem of the colonies of all countries owning them. In our issue of September 12 we dealt with a paper presented to the Institution of Civil Engineers by Mr. J. W. Spiller, in which he made a plea for the construction of more railways in the Gold Coast and other Colonies. He realised that these might not constitute commercial propositions, but held that their construction would be justified in helping the general development of the countries concerned. This is the basis of the whole matter of planning, and the only way in which it differs from the planning of a century ago is that it now has available for application a further hundred years of scientific progress. It has the further advantage, however, that the achievements of science in the past have led to a better realisation by politicians and administrators that, in such a potent and mysterious field, it is perhaps just as well to consult people who know something of the subject concerned. The extent to which planning is to be applied, however, remains a political matter. Scientific men may advise on the wisdom or possibility of a project, but it is not their business, as scientists, to determine whether it should be carried out. The expression "scientific men" in this connection must be given a wide comprehension. It must include skilled industrialists. A pure scientist is not necessarily a good adviser on practical problems. He may involve the administrator in a programme for the production of, say, reinforced white bread, which the industrialist could have shown to be impracticable from the first.

Planning will figure largely in the discussion of the problems which the end of the war will bring. To what extent it will be adopted is a political question to which no answer can be given at present. That scientific opinion will be more freely consulted than has been usual in the past is probable, but how far purely socialistic control will be extended to technical projects it is impossible to say. Considerable interest was displayed at the conference over the achievements recorded by the Tennessee Valley Authority. Those achievements are due to the application of scientific methods on a large scale, but the planning which led to them was a piece of socialistic activity. Schemes on the same scale are hardly possible in this country, but something of similar type might possibly be carried out in, for instance, the Highlands of Scotland. That a period which has seen the break-up of organised civilisation over a large part of the world should have resulted in aspirations for a future better than the past is natural, and is a credit to that part of mankind which is in a position to express its hopes and fears.

Nothing but disappointment can follow, however, if it is imagined that in some way science will prove the lodestone marking the way to a happier age. The application of the knowledge which scientific progress has accumulated over the centuries will enable the best to be made of material possibilities, but it is not within the competence of science to map out a path which will lead man a little nearer to the golden age. His own self-governing capacity must remain his guide.

THE FUTURE DISTRIBUTION OF THE INDUSTRIAL POPULATION.

One of the most interesting sociological inquiries of recent years, and one of the most unfortunate in its timing, was that of the Royal Commission on the Distribution of the Industrial Population. Originally appointed in July, 1937, the Commission lost no time in gathering the voluminous evidence that their terms of reference demanded; but the data collected on the 29 days during which the public inquiry lasted were not of a kind to be rapidly reduced to order and comparatively studied, and they did well to complete their report in little more than two years from the date of appointment. By that time, however—August, 1939—war was imminent, and it was not until January, 1940, that the report could be presented to Parliament. Inevitably, therefore, it was overshadowed by more urgent affairs, and received much less attention than was its due. Since then, there have been such changes in the distribution of industry and of the population of the country that many of the findings of the Commission, and certainly a great deal of the evidence on which they were based, appear now to have almost a historic interest, and it is a moot point to what extent their conclusions may require to be revised if they are to be of service as a basis for future administrative action.

The principal changes that have taken place during the war are obvious, and to a large extent must be regarded as transitory, but they may have incidental effects, difficult to assess in advance because they affect individuals rather than trades, though they may be sufficiently far-reaching in their aggregate influence to upset future plans if these are based on pre-war data. Thousands, perhaps scores of thousands, of the men and women now enrolled in the Forces of the Crown are acquiring a knowledge of other parts of the country and other occupations which would have remained a closed book if they had not been forcibly detached by the course of events from their former surroundings and means of livelihood. Hundreds of thousands of children from industrial centres are spending some of their most impressionable years in new environments, in which they cannot fail to learn something of occupations which may well become more attractive than the opportunities that would normally have been theirs on leaving school. Some old-established centres of miscellaneous industry have been largely evacuated; new centres have sprung up, not all of which can be expected to revert to their pre-war conditions; and the numerous Government factories, distributed for military reasons among districts where no ordinary industrialist would have contemplated locating them, will offer a direct inducement to decentralise post-war industry. Some of them are on such a scale as to constitute, without further expansion, nuclei for the establishment of considerable satellite towns of the type which some economists have urged as the only satisfactory antidote to such huge "conurbations" (to use a term much favoured by the Royal Commission) as those of London, Manchester, Merseyside, Clydeside, Tyneside and the Birmingham area. It is not to be expected that these new industrial centres will be abandoned after the war, whatever vague promises of restoration to pre-war condition may have accompanied the original acquisition of the property on which they stand.

Finally, there are the aerodromes and military training centres that the war has brought into being. Some of these, undoubtedly, will revert to their previous agricultural purpose; but many of them must be retained if the promises of Government spokesmen are implemented, that the maintenance of more adequate armed forces shall be a basic condition of post-war policy as contrasted with that of the pre-war years; and although no less an authority than Colonel Moore-Brabazon, the present Minister of Aircraft Production, questions whether ordinary industry will be able to support the cost of any extensive commercial use of long-distance air transport in peace time, there is no doubt that civil aviation will require a more generous provision of flying grounds and servicing facilities than was formerly available. All of these probable developments and tendencies are going to have some effect upon the distribution of industrial population after the war, though it is difficult at this stage to prophesy what that cumulative effect may be. An additional complication, almost impossible to evaluate in advance, will be the removal of present restrictions upon the normal operation of economic forces; for example, the Government are now paying out large sums to stabilise local rates at little more than their pre-war level. When this restraining influence is withdrawn, the inducement to small manufacturers, not too encumbered with heavy plant, to move out of the most heavily rated areas may be almost explosive in its scattering effect, unless some counter-inducement makes it worth their while to remain.

These movements of industry, or variations from the conditions obtaining before the war, are likely to have considerable bearing upon post-war schemes for obviating widespread unemployment in the transition period between war and established peace. It is understood that, apart from the essential work of reconstruction in areas that have been badly hit by enemy action, the Government have been preparing various plans for such large-scale public works as the modernisation of roads, and the carrying out of the many municipal developments of water supply, etc., which are necessarily held in abeyance during the war. The need for these in particular districts may prove, in fact, to be much less acute than was expected, if the present temporary migrations of the population should prove to be permanent to any considerable extent; and the problem will then arise, whether to accept the changes (whatever they may be) as permanent, or to use the development schemes, wholly or in part, as means for inducing new movements in directions which expert economic opinion may consider advisable.

Large movements of population certainly could be induced, if desired, by the provision of new amenities. There can be no more effective demonstration of this fact than the rapid urbanisation of the outlying districts of South London, following the electrification programme of the Southern Railway. So rapid was it as to suggest that, in tackling the problems of the "depressed areas," in the years before the war, the authorities would have done better to have concentrated on improving their communications, which were never more than mediocre, instead of offering special reduced-rate facilities and similar "ground bait" to encourage the establishment of new industries. The cases are not entirely parallel, perhaps, as the expansion of the London outer ring was residential rather than industrial on the whole, and much of it merely represented alternative accommodation for a population that was already employed in the London area: whereas the big towns in the depressed areas were themselves sharing in the depression. Nevertheless, the experience in the suburban districts of London does suggest that the decentralisation and dispersal of industry, which the Royal Commission recognised as being desirable features of future development, can be achieved in more than one way. The direct method, of offering financial encouragement to manufacturing firms to settle in specific areas, has been tried already, with results that are satisfactory up to a point, but which are not particularly far-reaching in view of the outlay involved. The indirect method, of enhancing the attractions of given districts until it is obviously advantageous to reside in them, seems to offer at least equal prospects of success; for the existence of a reserve of employable labour is one of the chief reasons which have always governed the location of manufacturing trades. The population is now dispersed to an extent that did not obtain when the Royal Commission gathered their evidence, and if this dispersal can be made more or less permanent, a substantial part of their recommendations will have been realised; but the present systems of railways and roads have developed on the basis of the older arrangement of industrial districts, and any new distribution of population and trade is bound to affect the flow of traffic, which the railways, at least, will want to restore to its former channels.

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE opening meeting of the 1941-42 session of the Institution of Mechanical Engineers will be held at the Institution, Storey's-gate, St. James's Park, on Friday, October 24, at 2.30 p.m., when the President (Mr. W. A. Stanier) will deliver his address, the subject being "The Position of the Locomotive in Mechanical Engineering." The notice announcing the meeting states that, in addition to the usual formal business transacted at ordinary general meetings of the Institution, there is an item of special business; namely, "the Council will, under By-Law 50, recommend that Mr. H. L. Guy, D.Sc., F.R.S., M.I.Mech.E., be appointed at this meeting by the Corporate Members as Secretary of the Institution, as from March, 1942." To many members, no doubt, it will be a surprise to learn that Mr. J. E. Montgomery, who was appointed assistant secretary in 1920 and succeeded Brigadier-General Magnus Mowat as secretary in March, 1939, will reach the normal age of retirement next year. Dr. Guy, who joined the Institution as a graduate in 1906, has taken a very active part in its affairs, especially in connection with the North-Western Branch, of which he was chairman in 1929. He became an associate-member in 1912 and a member in 1927, and served on the Council of the Institution from 1928 until the present year, since 1938 as a vice-president. Dr. Guy received his technical education at the Cardiff College of the University of South Wales and Monmouthshire, and was awarded a Royal Research Scholarship and a Whitworth Exhibition. He joined the Metropolitan-Vickers Electrical Company (then the British Westinghouse Company) in 1910, becoming chief engineer of their Mechanical Department in 1921. He has been closely identified with much original research and development work in connection with steam and the steam turbine, and was elected a Fellow of the Royal Society in 1936, and a member of the Council of the Royal Society two years later. In 1939, the University of Wales conferred on him the honorary degree of D.Sc. Recently he was invited by the Royal Society to join the Executive Committee of the National Physical Laboratory, and, following the death of Sir Nigel Gresley, he was elected chairman of the Engineering Research Committee of the Laboratory.

AUTOMOBILE RESEARCH.

As the internal-combustion engine, and the mechanisms associated with it, play such vital parts in the present struggle, it is highly satisfactory to learn that the work of the Automobile Research Committee of the Institution of Automobile Engineers is continuing without interruption. The Tenth Annual Report, which has just been published, dealing with the Committee's activities in the year ended on June 30, 1941, is a record of uninterrupted progress. Naturally, work on some items in its programme has been suspended to permit attention to be given to more urgent matters, but its activities as a whole have been in no way curtailed and it has been possible to retain the services of the whole of the technical staff, apart from a number of junior laboratory and workshop assistants. As an example of change in the type of problem to which attention is being given, the work on motor-cycle silencing has been suspended, but much time has been devoted to the question of the aeration and frothing of lubricants. This matter is of immediate importance in its application to aero engines. The subject is being dealt with from the points of view of the production of froth in lubricating oil; the separation of air from the oil; and the effect of aerated oil on bearing performance. Other matters which have occupied the attention of the Research Laboratory during the year are the performance and wear of bearing metals, the performance of a converted petrol engine running on producer gas, gear performance, and piston-ring scuffing. In connection with bearing performance, the report points out that bearing difficulties occur with persistent regularity. Improvements in material and design may ease the situation for a time, but in due course demands for increased engine output result in bearings again reaching the limit of their load-carrying capacity with the possibility of new difficulties arising. There is no doubt that one of the main problems of the aero-engine manufacturer is to keep mechanical design abreast of requirements. The only work for the Research Committee which is now being done outside its own laboratories is that on deep-drawing, which is being carried out in the Engineering Department of Sheffield University, under the direction of Professor H. W. Swift. This work is of interest in a wide range of manufactures and is being supported by the British Iron and Steel Federation, the British Non-Ferrous Metals Research Association, the National Association for Rolled and Re-rolled Steel Products, and a number of industrial concerns. The report points out that work on gear performance is similarly of interest to many outside the automobile field and a Research Sub-Committee has been constituted to draw up a programme of work which it is hoped will be assisted by outside interests. The report is presented by Mr. W. A. Tookey, who has been re-elected as chairman of the Automobile Research Committee, and Dr. E. Giffen, the director, who took office during the year covered by the report, the late director, Dr. C. G. Williams, relinquishing office at the end of September, 1940. The total number of affiliated members of the Research Committee at the end of the year was 305, which is exactly the same as in the two previous years. There was an increase in members' subscriptions to 9,264*l.*, as compared with 8,647*l.* in the previous year, and the accounts show an excess of income over expenditure of 451*l.*, as compared with a deficit of 807*l.* This satisfactory position is partly explained by the fact that no large expenditure on plant was made during the year, and in view of the necessities of the future it is hoped that income will continue to expand, to enable a reserve fund to be built up.

THE FEDERATION OF BRITISH INDUSTRIES.

On October 8, the Federation of British Industries observed the 25th anniversary of its foundation. The President, Lord Dudley Gordon, D.S.O., speaking at the meeting of the Grand Council on that day, said that the Federation had pledged its services to the Government at the outbreak of the war, to help in all ways in its power, and had since been in frequent and close consultation with the Government. Its advice was offered in no sectional interest, but on behalf of all engaged in industry, in whatever capacity. Referring more specifically to the Federation's part on the Central Joint Advisory Committee to the Production Executive of the War Cabinet, Lord Dudley Gordon said that, on this committee, they co-operated on happy terms with the British Employers' Confederation, which represented organised industry on labour questions, and with the Trades Union Congress. The Federation had recently presented to the Production Executive the considered views of industry on certain major aspects of organisation for war production. Consideration of those views by the Government and by the Advisory Committee was proceeding. Progress was being made with the creation of capacity clearing centres under the Regional Boards, to which the Federation attached great importance. At the moment, their one task, as a corporate body and as individuals, was to do their utmost to win the war. They had consistently advocated that, to achieve the best possible production, the Government should take industry fully into their confidence at the earliest possible stage, in order that industrial experience might be available from the outset in planning production and in the organisation necessary to achieve it. This could be done both centrally, by organised trades, and locally, through the regional organisation of the Production Executive. Although much remained to be done, great results had already been achieved; it was no service to the national cause to give the impression that the war effort of the country was not already of a stupendous nature. Turning to the subject of exports, Lord Dudley Gordon emphasised the future danger that would result from any drastic severance of export connections, even for a short period. Industry realised that further restrictions of exports might be necessary, but urged that industrialists should be told frankly precisely what goods could be exported, to what extent, and to what markets; and what goods must be regarded, for the moment, as incapable of export except to certain limited destinations. In considering post-war problems, the Federation looked forward to close consultation with the British Employers' Confederation. If British industry was to be in a competitive position after the war, it must be able to deal with such questions as redundancy of factories and equipment, surplus stocks, falls in stock valuation, and many other factors, and to set working once more the export trade on which so many of the industries of the country depended. To mark the occasion of the 25th anniversary of the establishment of the Federation, the Grand Council sent a message to the Prime Minister, assuring him that "the F.B.I., which came into being in the midst of the last Great War, is proud once again to help in the marshalling of the forces of production to the single end of victory." Mr. Churchill, in his reply, expressed "the gratitude of His Majesty's Government for the magnificent contribution which all sections of industry have made and are making to the war effort," adding that "we value their counsel, we welcome their advice and assistance."

THE BRITISH EXPORT TRADE AGREEMENT.

On page 233, *ante*, we gave details of the agreement concluded between the British and the United States Governments, the purpose of which was to ensure that no materials supplied to this country under the Lend-Lease Act should be used by British industry in the manufacture of goods for export to markets where they would be in competition with similar products from the United States; especially if the materials were of kinds, the use of which was being restricted in the United States in order to release as much as possible for Britain and the allied nations. Actually, of course there is no opportunity to use American supplies in such a way, because all exports of goods covered by the undertaking are controlled by the British system of export licences; but this fact is not widely realised in the United States, and there is reason to believe that public opinion in that country is tending to draw incorrect conclusions from the continued appearance in British periodicals which circulate overseas of advertisements of goods falling within the categories covered by the agreement. Not only is this so, but isolationist agitators in the United States are reported to be using these advertisements as propaganda, to suggest that, although the British Government has entered into the agreement, British industrialists are seeking to evade its obligations. In the interest of Anglo-American good relations, it is of the highest importance that such suspicions, totally unfounded as they are, should not be allowed to gain ground. By far the greater part of the advertising undertaken by British engineering firms at the present time is solely directed to the maintenance of goodwill; and the fact that goods, made of raw materials which are in short supply as a result of the war are advertised in ENGINEERING is not necessarily an indication that they are available for export. In some cases, indeed, firms may be advertising goods that they have temporarily ceased to make at all. The reasons for modifying the export policy that was so strongly stressed in the earlier stages of the war are explained more fully in the official statement by Mr. Harcourt Johnstone, M.P., Secretary of the Department of Overseas Trade, which is printed on page 315 of this issue.

NICKEL AMALGAMS.—In a recent issue of the *Journal of the Chemical Society of Japan*, Mr. N. Kato describes the production of a nickel amalgam, containing 4·37 per cent. nickel, by the electrolysis of nickel sulphate solution, using nickel as anode and mercury as cathode.

INSTITUTE OF FUEL.—A luncheon was held at the Connaught Rooms, London, W.C.2, on October 15, preceding a meeting of members of the Institute of Fuel. At the meeting Mr. W. M. Selvey, Wh.Ex., M.Inst.C.E., M.I.Mech.E., M.I.E.E., was installed as President for the 1941-42 session by the outgoing President, Lieut.-Col. Sir John Greenly, K.C.M.G., C.B.E., and the Melchett Medal for the year 1941 was presented to Dr. C. A. Seyler, F.I.C., of Swansea.

ECONOMIC CONTROL IN INDUSTRY.

By F. L. Meyenberg, M.I.Mech.E.

(*Continued from page* 144.)

The industrial concern has been defined as an undertaking that transforms raw material into saleable goods by human labour. The more industrial activity develops the more numerous and complicated become the various categories of plant, and the more it is necessary to keep them clearly in view. Therefore the idea of economic control leads first to a careful inventory of those auxiliaries to production which may be termed "fixed" works property, from the point of view of accountancy, in contrast with "floating" works property; and secondly to a consideration of the means of keeping them continually in good working condition.

The main groups of these auxiliaries are as follows: (1) factory estate, with roads and fences; (2) buildings, with their water, heat and power and drainage services; (3) machinery; (4) tools, gauges, jigs, fixtures, etc.; (5) patterns; and (6) patents. The necessity of an inventory will be generally agreed, and there are few works where an original list could not be found; but whether it is up to date is another matter. Certainly, it is not easy to develop arrangements that will ensure this without becoming cumbersome and uneconomical; nevertheless, it must be done.

It is seldom necessary to set aside a reserve for depreciation of the land itself, as the value of land tends to increase rather than to diminish; it is usual, therefore, to keep this at a constant figure. Roads and boundary fences or walls should be dealt with in the same way as buildings and are best classified with them. In this connection, reference may be made to the horticultural and other embellishments which are to be seen in many modern factories, though they are sometimes still considered as not essential to commercial success, the only purpose that a works should have. They serve to prevent the use of free space as a dump for scrap, to increase, perhaps subconsciously, the employees' pleasure in their work, and finally to create a favourable impression in the minds of visitors, with probable benefit to the business.

The structure of buildings and the plant installed in them should be kept strictly separate, as the character of their depreciation and maintenance is quite different. Of course, this distinction is artificial to some extent, as the connection between the structure and its contents is often very close; it is sound policy to allocate doubtful items to the plant, with its higher allowances for depreciation. One item in particular may be mentioned, neglect of which frequently causes trouble: plans of all pipelines, cables, etc., inside and outside the buildings, should not only be kept readily to hand, but should be maintained continuously up to date.

The two next groups, machinery, and tools and implements, respectively, suffer from the difficulty that it is almost impossible to define clearly where the one ends and the other begins. All efforts to develop general definitions suitable for any case have failed, and, so long as no accepted standardisation exists, the individual works is obliged to develop regulations of its own for the classification of the various items into the different groups and subgroups. Some such a classification seems unavoidable for practical reasons; to consider each item separately for depreciation purposes may be excellent in theory, but it involves such a cumbersome clerical system that the result either ceases to be economical or develops into a mechanical routine, more superficial in effect than grouping would involve.

Of the many problems which arise from the depreciation of machinery, a few typical examples may be mentioned. What value should be taken as a basis if a new machine tool has been bought and erected on site; should it be the invoiced price only, or should the cost of carriage to the works and, perhaps, of erection at site be included? Are the accessories supplied with the machine to be reckoned as a part of it, whether or not they have been specially designed to be used in conjunction with it? The answer is more or less a matter of opinion; but some rule must be laid down and adhered to, or confusion may result which would endanger the whole policy of depreciation.

To be able to develop such a policy, it is necessary first to understand what is implied by the term depreciation in this connection. Depreciation may be regarded as capital, invested in fixed property, which is in process of transformation into floating property, either by use or by merely standing idle, but prepared for possible use. Thus a lathe is fixed property which is transformed gradually into floating property, that is, into goods finished by its aid; the change being partly the result of the wear and tear of the lathe during its actual use and partly the equivalent of additional wear and tear represented by its progressive obsolescence.

The wear and tear, roughly speaking, is proportional to the severity and duration of the work done by the machine; and the obsolescence, though partly proportional to the age of the machine, also depends in part on such external circumstances as the influence of new inventions and designs. It follows that depreciation can never be calculated mathematically but must always be based on estimation. That means that, while calculation to a penny, etc., is absurd, all available expert knowledge should be used to arrive at a correct estimate of depreciation; for this will determine whether part of the invested capital is distributed as profit by estimating the depreciation too low, or whether sales policy is rendered unnecessarily difficult by an excessive depreciation reserve.

On the other hand, sound business policy will ensure that the amount reserved for this purpose, and based on expert estimation, is really spent on the replacement of worn-out and obsolete machinery; to cut down such expenditure may appear to be economy, but is really very far from it. Actual percentage figures can be taken from textbooks, if direct experience is lacking; but careful statistics should provide these figures and they should be checked from time to time according to the technical development and special circumstances of the particular works. Experts differ in this matter; cases are known where the average age of machine tools in a successful works engaged in general mechanical engineering was 14 years to 15 years, while an American writer suggests six years, giving as one reason for this short period that it is then possible to sell the discarded machines for 60 per cent. to 70 per cent. of their original cost.

Another conclusion to be drawn from this examination of the meaning of depreciation is that there is no fundamental difference between depreciation and complete writing off into overheads, the latter being, so to speak, a 100 per cent. depreciation. There is no real distinction between machines and tools; machines are depreciated, and tools are charged as overheads from the moment that they begin to be used. In principle both groups of property must be depreciated, but the degree of depreciation is different; and if the value of some tools is entirely written off immediately after they are put into service, that is rather a matter of convenience than a true reflection of the facts. A new hammer may break at the first blow, while one that does not will probably last for years. It is not possible to cover all variations of this kind by any system of depreciation, nor is it suggested that any attempt should be made to do so; though it is advisable to keep such points in mind and to consider from time to time whether, and where, improvements can be made in the system. In any case, machinery, tools and implements should be grouped in their appropriate classes for depreciation purposes. The works manager, the maintenance engineer and the accountant should co-operate in this grouping, which should be reviewed, say, once a year, to take proper account of any changes in working conditions.

Similar considerations apply also to the last two groups of fixed property, namely, patterns and patents. Where the financial conditions of the business allow, it is not unusual to write off the value of such items completely as soon as they arise; but, again, it is a question whether this simplification may not give a wrong impression of the financial position. Concealment of reserves may be sometimes justifiable in published balance sheets, but must be avoided in internal statements; figures depreciated by manipulation of this kind cannot give a correct basis for costing.

Maintenance is the second problem associated with fixed works property. Correct management avoids breakdowns by timely repairs. A carefully worked out system of overhauling, strictly adhered to, may seem to be expensive, but usually it pays in the long run. It is generally possible to build up a budget for the maintenance department, and to obtain a definite basis for costing purposes, by determining a standard manning figure for this department covering the needs for normal overhauling, with a suitable surplus for rush work in case of breakdown. This provides an effective control over the tendency towards overstaffing to which maintenance departments are liable, especially when the works are slack. Here, again, however, an overdose of control can easily have detrimental consequences. For example, the frequently used system whereby the manager of the maintenance department can undertake on his own responsibility only such repairs that do not exceed a certain limit of cost is simply red tape; he must be a man of sufficient experience and integrity to be trusted not to allow any extravagance. In any case, it is obvious that larger repairs can be easily carried out in instalments without violating the letter of the instruction. It is a sign of wise management to avoid regulations which are psychologically wrong and can be easily eluded.

There is an additional check on the risk of too costly repairs in the fact that the manager of the department for which the repairs are carried out, and against which they will be charged, will watch any expenditure that is likely to increase the cost of his own output. Sometimes, especially in very large works, this has led individual departmental managers to engage their own repair fitters, on the pretext that they can do the work more cheaply than the maintenance department. This may be true in the case of very small jobs, but it certainly does not apply to major repairs or to the general overhauling of plant. A suitable compromise is to entrust small jobs to the man in charge of the tool store in the department concerned, who may be an elderly fitter or toolmaker. If, for easy interchange of tools between various shops, these stores are placed under the authority of the toolroom superintendent or the maintenance engineer, the advantages of decentralisation may be obtained without its drawbacks.

Closely connected with the question of maintenance is the stocking of spare parts, which may lock up a considerable amount of capital. Whether these parts should be supplied from outside or produced in the works can be decided only after a fair comparison of the costs of both cases, but usually it is better to obtain them from the original supplier of the machinery.

Considering the nature and variety of the work to be done by a maintenance department, its occasionally urgent character which may necessitate much overtime, and the difficulty of effectively controlling the quality of the work as well as the time taken, it is evident that only men of proved skill and dependable character should be employed in it. Employment on maintenance should be regarded as promotion and be paid accordingly. It will seldom be possible to pay them by the piece, but the hourly rates should be fixed generously; it will pay in the long run. Cheap repairs are usually the most costly; therefore a low maintenance account should never be considered worth striving for.

(*To be continued.*)

Antimony-Steel Alloy.—An alloy has been recently patented in Germany with the following percentage composition:—carbon, 0·03 to 0·5; antimony, 15 to 18; sulphur and phosphorus, 0·03 to 0·3; molybdenum, 0 to 5; tungsten, 0 to 5; and the balance iron. The alloy is stated to be very resistant to attack by hydrochloric acid, and it appears that optimum results are obtained with 0·03 to 0·2 per cent. of carbon. For certain purposes, 0·01 per cent. to 0·3 per cent. of beryllium may be added.

LETTER TO THE EDITOR.

THE TIDE-GENERATING FORCES.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. J. S. Tawresey's letter in your issue of September 5, and Dr. Doodson's in your issue of September 26, have done much to clear up the difficulties and misunderstandings with regard to the tide-generating forces. My letter of August 22 was based solely on Dr. Doodson's article in your issue of May 23. It was partly because Dr. Doodson in his article did not give a clear explanation, that I could not understand his definition of relative or differential forces. I thought it was only necessary to consider the variations or differences in the attractive force of the moon at different points on the Earth's surface. I reached this conclusion the more readily because Dr. Doodson made no mention of the centrifugal force due to the revolution of the Earth round the Earth-moon centre of gravity, and I did not then realise the importance to be attached to this centrifugal force as one of the important forces concerned in generating the tides. Now that I understand Dr. Doodson's explanation I withdraw the alternative explanation of the tidal humps which I suggested.

In his letter of September 26, Dr. Doodson states "that there are three well-known ways of deriving the tide-generating forces." Stated briefly, these are: (1) that which considers the relative or differential forces acting at different points; (2) that which considers the attractive force of the moon and the centrifugal force due to revolution about the Earth-moon centre of gravity; (3) that which considers the potential of the forces.

The first method is that followed by Dr. Doodson. If the attractive force of the moon on all the particles of the Earth were equal (in intensity and direction) to the force at the centre there would be no movement of the particles relative to one another and therefore no tidal movement. It is because the attractive force of the moon is different at different points, being greater at points on the surface towards the moon and less at points on the surface away from the moon than the force at the centre, that there are tidal movements. It is clear that the force causing these movements is measured by the difference between the actual attractive force at the point considered and the force at the centre supposed to be acting at the point. Further, since only horizontal components have to be considered, the effective tractive force will be measured by the difference between the horizontal components of the two forces.

It is necessary to consider also the direction in which this horizontal tractive force acts. Suppose first that the point considered is on the surface towards the moon. In this case, both horizontal components act towards the line of centres of Earth and moon and the horizontal component of the actual attractive force of the moon is greater than that of the force at the centre. The effective tractive force, which is the difference between the two components, acts therefore towards the line of centres. The direction of the horizontal component of the actual attractive force is taken as the positive direction. When the point considered is on the surface away from the moon both horizontal components act away from the line of centres, but the horizontal component of the force at the centre of the Earth, supposed to be acting at the point, is the greater. Hence the direction of the tractive force is negative, that is, it will act towards the line of centres. Thus at points on both surfaces the tractive force acts towards the line of centres. This is a point which was not clearly explained by Dr. Doodson in his article.

The second method is the one followed by Mr. Tawresey. When the point considered is on the surface towards the moon, the horizontal component of the centrifugal force acts away from the line of centres and is less than the horizontal component of the attractive force of the moon which acts towards the line of centres. When the point is on the surface away from the moon, the horizontal component of the centrifugal force acts towards the line of centres and is greater than the horizontal component of the moon's attractive force. The tractive force is measured by the difference between the two horizontal components and acts in the direction of the greater. Thus it will be seen that the tractive force acts towards the line of centres whether the points considered lie on the surface towards the moon or on the surface away from the moon.

Another point should be noticed. Mr. Tawresey has shown clearly that if the attractive force of the moon acting at a point were equal (in intensity and direction) to the attractive force acting on a particle at the centre of the earth there would be no horizontal tractive force. In this case the horizontal component of the moon's attractive force would be equal and opposite to, and would therefore balance, the horizontal component of the centrifugal force at the point. It is, of course, only at points on the great circle at right angles to the line of centres that the attractive force of the moon is practically equal to the attractive force acting at the centre. It is evident, however, that in estimating the tractive force at any point we could substitute for the horizontal component of the centrifugal force the horizontal component of an attractive force equal to the force acting at the centre of the Earth, but supposed to be acting at the point. If this were done, the way in which the tractive force is estimated in this second method would be modified so as to become identical with the way in which it is estimated in the first method followed by Dr. Doodson. From this we can recognise clearly the equivalence of the two ways of deriving the tide-generating forces. I believe, however, that the second way of looking at things will be preferred by practical men.

The third way of deriving the tide-generating forces is highly mathematical, and will make no appeal to those who do not lay claim to any special mathematical knowledge.

Yours faithfully,

J. M. L.

October 7, 1941.

OBITUARY.

DR. W. R. ORMANDY.

DR. WILLIAM REGINALD ORMANDY, the well-known authority on liquid fuels, died on September 12, at Moreton, Wirral, Cheshire. He was born at Chorley, Lancashire, on October 25, 1870, and received his early education at Wigan Grammar School. He then attended the School of Mines, Wigan, and afterwards spent five years at Owen's College, Manchester, gaining a Bishop Berkeley Fellowship and other honours. Subsequently, he went to Tübingen University for three years and obtained a D.Sc. On returning to this country he was appointed research chemist in the glass works of Messrs. Pilkington Brothers, Limited, and afterwards joined the staff of the St. Helens Cable and Rubber Company, Limited. He then left industrial work and accepted an appointment as head of the Science Department at St. Helens Technical School, but remained in this position for only two years. After acting as chief research chemist to Messrs. Joseph Crosfield and Sons for some years, Dr. Ormandy opened a private practice as consulting and research chemist and engineer. He was specially interested in liquid fuels and in the electro-osmotic treatment of refractories, and was a recognised authority on all problems concerning hydrogenation and other synthetic processes, and the distillation of petroleum and alcohols. He was a member of the Inter-Departmental Committee on Alcoholic Fuel and also served on the Imperial Motor Transport Fuel Committee and on the Empire Fuel Committee. Dr. Ormandy was for many years a Fellow of the Chemical Society and a member of the Society of Chemical Industry and of the Chemical Engineering Group. He was elected a member of the Institution of Automobile Engineers in 1913 and later served as president. He joined the Institute of Petroleum in 1914, the Institute of Metals in 1918, the Institute of Chemistry in 1919, the Institution of Chemical Engineers in 1926, and the Institute of Fuel in 1927.

EXPORTS TO THE UNITED STATES.

IN reply to inquiries, Mr. Harcourt Johnstone, M.P., Secretary of the Department of Overseas Trade, has issued the following official statement (which has been slightly abridged) to remove misunderstandings on the subject of exports to the United States.

In order to import the great volume of munitions and other vitally important goods which we wished to obtain from the United States, the United Kingdom was obliged, so long as the rule of "cash and carry" prevailed, to force out to the United States the maximum volume of exports. This was one of the purposes of the so-called "export drive" of the early months of 1940; and when the collapse of France made necessary concentration upon the production of war materials, and exports had to be more carefully husbanded, the United States remained the most favoured market. It was vitally important to ensure exports to countries with dollar currencies, or whose currencies were readily convertible into dollars, and those exports to the sterling area which fulfilled requirements that would, unless supplied by the United Kingdom, involve these countries in payments in dollars. We were prepared, if necessary, to restrict supplies to the civil population in order to do so; and United Kingdom exporters were assured that their work was second only in importance to the actual production of munitions, and great efforts were made by them. Our exports to the United States in the first half of 1940 were considerably greater in value than in the same period of 1939, and were maintained above the 1939 level during the first half of 1941, in spite of the great difficulties of the second half of 1940.

By the passing of the Lease-Lend Act in March, 1941, the situation was profoundly changed. Not only was the strain upon our dollar resources immensely relieved, but as the volume of military supplies put in process of manufacture for us mounted, the United States administration, already occupied with its own defence programme, found it necessary to place restrictions upon the civilian use of some of the more scarce materials, and it became at once an obligation upon H.M. Government to see that the American manufacturer or exporter, who was stinted or deprived of his raw materials in order that such materials might be sent to us, should not find United Kingdom exporters offering manufactures of these materials to his own customers. H.M. Government therefore adopted the policy embodied in the statement issued as a White Paper (Cmd. 6311) on September 10, and undertook to see that the materials obtained under the Lease-Lend Act, which are required for the prosecution of the war effort, should not in any case be diverted to the furtherance of private interests.

This radical change of policy has inevitably caused many difficulties, and has led to a good deal of misunderstanding. The United States manufacturer or exporter has not always realised that the delivery of goods, which have arrived in United States or Latin-American markets in the days of Lease-Lend, was planned in the days of cash and carry; and since the machinery of trade cannot be changed overnight, he has found advertisements, still appearing, of goods which he thinks the United Kingdom exporter should not, and which in fact the United Kingdom exporter could not, now deliver, while, on the other hand, it has been baffling to United Kingdom exporters to find that some of their long-prepared plans to earn much-needed dollars must now be dropped. But the national gain is immeasurable. We are now in a position to obtain many essential imports without the necessity of finding dollars for them, and in this way we are enabled to save some of the energies which had formerly to be devoted to the export trade and turn them to more direct war purposes. It is from the point of view of war economy, a gain and not a loss, that we need no longer send scarce materials across the Atlantic in order that they may be turned into dollars and come back in the shape of munitions of war, but can devote them directly to the manufacture of war supplies here.

But this does not mean that a high level of export trade to the United States is either unnecessary or impossible. Our dollar needs are still very large, larger than any volume of visible export trade which we can hope to maintain will wholly provide. We are still importing many things from the United States outside Lease-Lend arrangements. In return for this we can send to the United States a large range of manufactured goods made from materials which can be spared by the munitions industries, and, by the same token, not constituting an offer to the American consumer of something which his own producers are precluded from providing him with. The main traditional United Kingdom exports to the United States are, of course, whisky, raw wool, woollen goods, linen, some specialities in cotton, apparel and tin. Other traditional exports, of importance in the aggregate, are some coal and non-metalliferous products, earthenware, and some kinds of glass, certain speciali-

ties in machinery, and leather and skins (where the humble rabbit is important). These exports are, to an unusual extent in British trade, largely made from home-produced material. Home consumption has been drastically reduced in some cases, of which the main examples are whisky, wool, and linen, in order to free the resources for export.

OIL-TRANSPORTING TRUCK.

The range of workshop equipment manufactured by Messrs. Alfa Laval Company, Limited, Great West-road, Brentford, Middlesex, has been extended by an oil-transporting truck. The purpose of this truck is the conveyance of clean cutting oils and other cooling media from the storage points to the machines in a workshop, and that of dirty oil from the machines to the purifying plant. The tank is rectangular and is approximately 4 ft. 5 in. long by 2 ft. wide by 1 ft. 6 in. deep. It is divided longitudinally by a partition so as to form two compartments, each holding 30 gallons of oil. If desired, each tank can be constructed to hold 40 gallons. The top is covered partly by a permanent plate and partly by a hinged lid. The tank is carried in an angle iron frame mounted on three swivelling castors arranged in a triangle in plan and having ball bearings and rubber-tyred wheels. A propelling handle, which may be folded up out of the way, is attached to the single castor. Two ½-in. semi-rotary pumps are carried on the angle frame at the end opposite the handle. These pumps are provided with suction and discharge pipes having three-way cocks. Each of the pipes has a connection to the tank, as well as a branch screwed to take a union on 7 ft. 6 in. lengths of flexible metallic hose, the lengths of hose being secured to the frame by spring clips during transport of the truck.

The three-way cocks enable the pumps to be used as follows: When taking a charge of clean oil from the storage tank, a length of hose is attached to the suction inlet of the pump and to the storage tank, and the cock is turned so as to cut off the pump suction from the compartment of the transporting tank. The cock on the pump discharge is turned so that the oil is pumped into this compartment, an operation which can be carried out at the rate of four gallons per minute. On arriving at the machine, the length of hose is coupled to the branch on the discharge pipe and led to the machine tank, and the two three-way cocks are reversed. The oil is then drawn from the compartment of the transporting tank and discharged through the hose. The other compartment is intended for the conveyance of dirty oil and the procedure adopted is the same as that described above. The oil is withdrawn from the machine tank and delivered to the second compartment, to be discharged later to the purifying plant. The transporting truck is easily handled and the connections quickly made, so that it should enable what is usually a somewhat dirty job to be performed cleanly and without loss of time.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

The Council of the Institution of Electrical Engineers have given careful consideration to the practicability of arranging a programme of meetings, in London, during the first half of the forthcoming 1941-42 session. It has been decided to hold monthly ordinary meetings of the Institution and also monthly meetings of the Installations, Meter and Instrument, Transmission, and Wireless Sections, the dates of the meetings of the four sections being arranged so that all meetings are spread out as evenly as possible throughout each month. To meet the conditions in the darkest months of the winter, the time of 4 p.m. has been selected for all the meetings, except the December meeting of the Transmission Section and the joint meeting of that section with the Meter and Instrument Section in January, which will be at 3 p.m. It is not proposed to hold any informal meetings, except those of the Wireless Section, until next spring, when the longer hours of daylight will permit of evening meetings. The programme will be subject to cancellation or modification, due notice of which will be given in *The Times* and *The Daily Telegraph* and repeated in the *Journal* of the Institution. In the event of cancellation of any meeting, the same arrangements as last session will be made for the issue of advance copies of the paper, and members will be invited to submit written discussions. These will be published in the *Journal*, together with the author's reply. It has been left to the committee of each local centre and sub-centre to decide whether any programme of meetings is practicable, separate notification of which has been, or will be, made to the local members in the usual manner. This also applies to students' sections, the committees of which are acting with their respective parent committees.

LABOUR NOTES.

The Ministry of Labour and National Service states that the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed on September 15 was 100,048—a decrease of 16,079 compared with August 11. Of the total, 30,462 had been classified by interviewing panels as unsuitable for ordinary industrial employment. Those registered as on short time, or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment, numbered 7,924; this was a decrease of 7,642 compared with August 11. Those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 9,511—a decrease of 2,471.

Corresponding figures for women and girls on September 15 were 96,546 wholly unemployed (of whom 3,477 had been classified by interviewing panels as unsuitable for normal full-time employment and 3,088 had been classified as unable for good cause to transfer to another area although employment was not likely to be available locally), 16,049 temporarily stopped and 543 unemployed casual workers. Compared with August 11, the numbers wholly unemployed showed a decrease of 7,098, those temporarily stopped a decrease of 6,335, and unemployed casual workers a decrease of 43.

Mr. Lemass, Eire Minister for Supplies, stated in Dublin last week that the Eire Government and the British Government had arranged a new scheme for the control of emigration from Eire to Britain. In future, all applications for employment in Britain made by Eire citizens direct to the British Ministry of Labour, are to be referred back to the Eire authorities for examination, and the active personal recruitment of workers in Eire by agents of British employers is to cease. Only to those not employed, or for whom employment in necessary work is not available in Eire, will permission be given for employment overseas.

Mr. Lees-Smith, the Labour Member for Keighley, asked the Prime Minister in the House of Commons last week if any representative of the Government was attending the conferance of the International Labour Organisation at New York towards the end of this month in addition to the delegates. Mr. Churchill replied that the Lord Privy Seal (Mr. Attlee) would represent the British Government at the gathering. Speaking at Cambridge later in the week, Mr. Attlee said that it was surely a thing of the highest significance that in the midst of the present life and death struggle a meeting should be held to discuss problems relating to the standard of life of the workers. Even in the midst of war, we should be thinking of the problems of the peace, and, so far as we might, endeavour to carry out in our own domestic sphere the principles which we believed to be fundamental to world peace. The British Government had already taken many steps to maintain and improve labour standards.

The seven members of the Conservative Party who are to discuss with representatives of the Trades Union Congress General Council the possibility of amending the Trade Disputes and Trade Unions Act, 1927, are to be:—Sir Cuthbert Headlam, M.P., chairman of the Central Council of the Conservative Party; Major Maxwell Fyfe, M.P.; Major R. G. Proby, chairman of the Eastern Counties Area Council; Sir Charles Davis, chairman of the Leeds Conservative Association; Mr. Gwilym Rowlands, M.P., chairman of the Party's Central Labour Advisory Committee; Mr. Tom Howard, formerly M.P. for South Islington; and Mr. Robert Catterall, a member of the Lancashire and Cheshire Labour Advisory Committee. The names of the trade union representatives were given in a recent issue. The parts of the Act which the unions desire to have repealed are Sections 5 and 6, which (*a*) prohibit affiliation of the Civil-Service trade unions with the Trades Union Congress, and (*b*) make it illegal for public authorities to insist that employees shall, or shall not, be members of trade unions.

A resolution was adopted at a meeting of the London District branch of the Electrical Trades Union supporting the action of the Edinburgh Trades Union Congress in expressing disagreement with the suggestions regarding wages in the Government's White Paper. It declared that the increases granted recently in various sections of industry were inadequate and laid on the workers "the major portion of the burden of the increased cost of living." The executive were called upon to demand improvements. A proposal to ask the executive to sanction a strike ballot of members in the London District, for or against enforcing a demand for a 3*s.* an hour minimum wage and a retrospective war bonus, was heavily defeated.

The unions and employers' organisations in the building industry have jointly drawn up wage rates and working conditions for women. Women employed in skilled trades such as bricklaying, plumbing and painting are to be paid at the rate of 1*s.* 6*d.* an hour after three months' experience and women labourers at the rate of 1*s.* 2½*d.* an hour. Overtime rates are to be on the same basis as those paid to men and where women are employed on scaffolding, they are to get "risk money." Women are not to be recruited unless the local trade union branch is satisfied that no male building-trade workers are available in the area, and no girl under 17 years of age is in any case to be employed. According to Mr. Coppock the women will be employed mainly on repairs on bombed houses.

Mr. Hudson, the Minister of Agriculture, last week received a deputation from the National Farmers' Union which urged him to postpone indefinitely the proposed call-up of 10,000 skilled land workers. The Minister was also asked to state what action the Government proposed to take with the object of enabling farmers to pay increased wage rates. Mr. Hudson replied that he was well aware of the labour difficulties involved. The Government, he went on to say, had postponed the call-up until the end of November, and the further question raised by the deputation was now being considered as part of the general problem of man-power. On the subject of wages and prices, the Government adhered firmly to the undertaking given in November, 1940, that "prices would be subject to adjustment to the extent of any substantial changes in cost of production." If, as a result of increases in wages, such substantial changes took place, the question of appropriate price adjustments would certainly arise and would be examined commodity by commodity. He recognised the desirability of making as early an announcement as possible on cereal prices for the 1942 crops.

The question of farm workers' wages was discussed in the House of Lords on Tuesday, when the Earl of Huntingdon called the attention of the Government to the need for immediately increasing the minimum wage paid to agricultural labourers. He stated that in spite of the use of machinery and the resultant increased productivity, the minimum wage remained at 48*s.* a week in many areas. He added that he was not asking for a uniform wage, but felt that there should be a minimum wage of 3*l.* a week throughout the country. In reply, the Duke of Norfolk, Joint Parliamentary Secretary to the Ministry of Agriculture, said that the present minimum national agricultural wage of 48*s.* was to be reviewed by the Central Agricultural Wages Board early next month. Consequently, it would be improper for the Government, having set up an independent body to fix a minimum wage, to influence its decision at this juncture. It was the Government's aim to ensure a prosperous agriculture after the war, including a decent standard of living for the agricultural workers.

Shop stewards are, it is generally agreed, useful trade unionists when they confine their activities within the four corners of the rules of the craft or organisation of which they are members. When, however, they combine, locally or nationally, with the shop stewards of other unions, they venture beyond the limits of their authority. The Amalgamated Engineering Union has made that clear enough on several occasions so far as its members are concerned. No shop steward can attend a local or national conference of shop stewards and pledge the A.E.U. to conform with any decision arrived at by it. The executive council have, therefore, directed district committees to inform all shop stewards under their control that they must not, as A.E.U. members, attend the conference called for this week to discuss production problems by the "Engineering and Allied Trades Shop Stewards' National Council."

Writing in the October issue of the official organ of the Transport and General Workers' Union, Mr. Arthur Deakin, the acting general secretary, says that in the course of the negotiations which have culminated in the formation of the National Dock Labour Corporation, every effort was made to secure all possible safeguards in the interests of the dock membership of the organisation. "I am confident," he continues, "that the scheme is workable and that it carries with it great opportunities for the development, within dockland, of better regulated conditions of employment and standards of life than were possible under the old casual system."

DOLOMITE BRICKS FOR STEELWORKS.

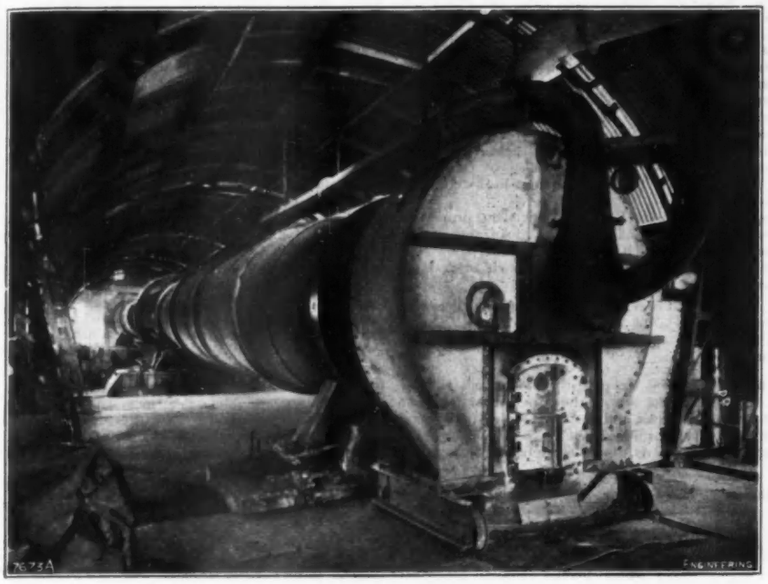


FIG. 1. ROTARY KILN FOR CLINKER PRODUCTION.

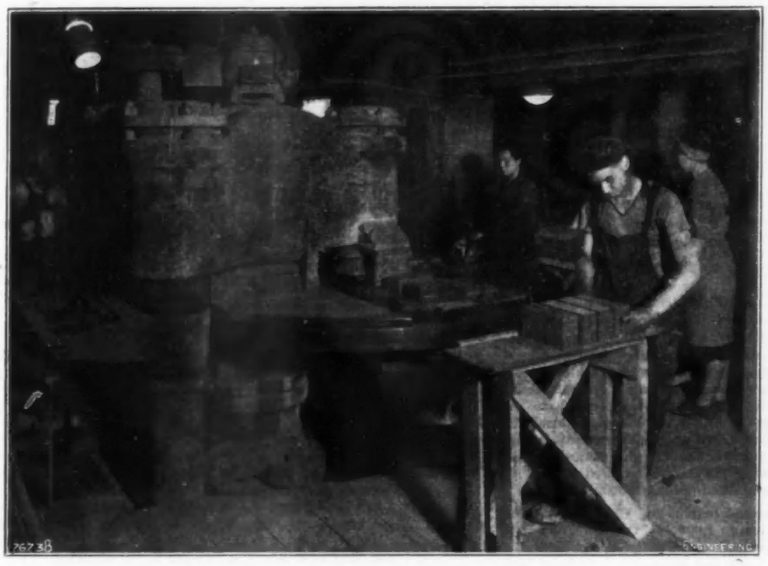


FIG. 2. HYDRAULIC PRESSING OF DOLOMITE BRICKS.

DOLOMITE BRICKS FOR STEELWORKS.*

By T. SWINDEN, D.Met., and J. H. CHESTERS, Ph.D., B.Sc.

THE object of the present paper is to draw attention to certain experiences in the use of stable and semi-stable dolomite bricks and to suggest that, in view of the increasingly difficult shipping position, even more use should be made of such home-produced refractories. In suggesting such replacement, the authors have borne in mind that the present-day furnace depends more than ever on the use of basic refractories in the back wall, front wall and ports for its high rate of steel production, and do not, therefore, recommend any change that would be likely to result in a loss of output

* Communication from the Central Research Department, The United Steel Companies, Limited, presented to the Iron and Steel Institute for written discussion. Abridged.

The crux of the dolomite-brick problem lies in the fact that high-temperature calcination (or even electrical fusion) of dolomite does not yield a stable product. Both the magnesia and the lime formed according to the reaction :—

$$CaCO_3 . MgCO_3 \rightleftharpoons MgO + CaO + 2CO_2$$

are of moderate crystal size (about 0·05 mm. in diameter), but the lime, unlike the magnesia, hydrates readily and samples of " basic " made in this way start to " perish " after only a few days' exposure to the atmosphere. The term " dead-burned " dolomite, considered literally, is, therefore, a misnomer and resort must be had to other means if satisfactory stabilisation is to be obtained. The ceramic literature of the last twenty years contains numerous suggestions as to how dolomite can be stabilised or the lime fraction removed altogether. Certain of the methods suggested are almost fantastic, while others, although showing promise, fall short of being a commercial proposition. Perhaps the first really successful experiments on a works scale were made in Great Britain, when, in 1934, bricks consisting of a 75/25 mixture of dolomite and Sudanite rock* (magnesite + talc) were found to give encouraging results in open-hearth furnaces.

Although the modern brick is made with a serpentine addition instead of Sudanite rock, and big improvements have been made in the methods of clinker production, grading, pressing, drying and firing, the general type and composition of all the stable-dolomite bricks now in use in Great Britain are essentially similar to those of the bricks made in 1934. Thus, bricks submitted to Messrs. Steel, Peech and Tozer in August, 1935, were shown to have the following properties :—

Analysis.	Per cent.	Analysis.	Per cent.
SiO_2 ...	... 13·24	MnO ...	... 0·05
FeO ...	... 3·21	CaO ...	... 39·64
Al_2O_3 ...	... 1·23	MgO ...	... 41·74

Properties.	
Porosity	... 22·4 per cent.
True specific gravity	... 3·32
Refractoriness under load	... 25 lb. per square inch.
Fail temperature ...	... Over 1,580 deg. C.

Comparison of the above results with data given later in this paper for the present-day brick serves to show that even in 1934 the dolomite brick was well on the way to success. These first bricks were made by firing clots of suitable composition, followed by regrinding, pressing in a small hydraulic press and firing in a baby kiln. They showed a serious brick-to-brick variation and periodically suffered from two serious limitations, viz., hydration in storage and " dusting " in the furnace.

Suggestions had already been made as to the cause of these difficulties, and complete confirmation came in February, 1936, when X-ray examination by Dr. A. H. Jay, of the Central Research Department (The United Steel Companies, Limited), in collaboration with Sir Lawrence Bragg, F.R.S., then of Manchester University, showed that the bricks which hydrated contained small amounts of uncombined lime, owing to an insufficient silica content or inadequate firing, while those which " dusted " (like an electric-furnace white falling slag) after use in the open-hearth furnace, contained γ dicalcium silicate. This work emphasised the necessity of adjusting the chemical composition so that all the lime was combined, but no unstable dicalcium silicate was present. It was therefore decided that the composition should be such that the principal constituents in the clinker were tricalcium silicate ($3CaO.SiO_2$) and magnesia, the reactions involved being essentially :—

$$\underset{\text{Dolomite}}{6(CaCO_3.MgCO_3)} + \underset{\text{Serpentine.}}{3MgO.2SiO_2.2H_2O} \longrightarrow$$
$$2(3CaO.SiO_2) + 9MgO + 2H_2O + 12CO_2.$$

Since a slight decrease in the serpentine addition below that theoretically required results in the presence of free lime, it is considered wise to keep slightly on the silica-rich side of the $3CaO.SiO_2$ composition. This may result in the presence in the clinker and fired brick of a little dicalcium silicate, and, hence, certain of the known stabilisers are added to the batch to prevent its inversion from the β to the γ form, a change that occurs below 675 deg. C. with a disastrous increase in volume. X-ray examination of numerous samples made during the last few years confirms that the main products are, in fact, magnesia and tricalcium silicate, but that small amounts of β dicalcium silicate may also be present. The state of combination of the alumina and iron oxide has not been ascertained at all definitely, although it would seem likely that they occur either as glass or as brownmillerite ($4CaO.Fe_2O_3.Al_2O_3$). One other reaction requires to be considered before the general principles involved can be understood, viz., the tendency of tricalcium silicate to break down at moderate temperatures—in particular, round about 1,200 deg. C.—to give dicalcium silicate and free lime :—†

$$3CaO.SiO_2 \rightleftharpoons 2CaO.SiO_2 + CaO.$$

The reaction is generally sluggish, but, as will be shown later, it can be troublesome in connection with the firing and subsequent storage of dolomite bricks.

Production of Stabilised-Dolomite Clinker.—The batch used consists of high-grade raw dolomite, together with serpentine and small amounts of stabilisers. The materials are first wet-ground in a tube mill and then pass to a slurry tank, where they are kept stirred until being fed into the top of a rotary kiln, shown in Fig. 1, on this page. The firing zone of the kiln is lined with magnesite bricks, although special dolomite bricks have been used recently with marked success. The kiln is fired with pulverised coal and attains a temperature in excess of 1,600 deg. C. As the slurry passes through the kiln it first loses water, then carbon dioxide from

* W. H Tyler and W. J. Rees, *Transactions of the Ceramic Society*, vol. xxxiii, page 104 (1934).

† E. Carlson, *Journal of Research of the National Bureau of Standards*, vol. vii, No. 5, page 896 (1931).

the dolomite. From then onwards, reactions occur which eventually lead to the formation of $3CaO.SiO_2$ and MgO. If the temperature in the firing zone is particularly high, the pea-size particles tend to grow and may even yield balls of clinker several inches in diameter. The red-hot clinker leaving the bottom of the kiln passes through a cooler and thence via elevators to the crushers. The crushed product is mechanically sieved and the sieve fractions are stored in steel hoppers.

The various grades of clinker obtained in this way are recombined by weighing out fixed quantities of the different grain-size fractions and conveying them to a mixer. The grading of the batch varies somewhat from plant to plant, but the following may be considered a typical range :—

Coarse	... ...	75 per cent. to 55 per cent.
Medium	... ...	15 „ „ 5 „ „
Fines	... ...	40 „ „ 20 „

The batch is moistened with about 4 per cent. of water, and weighed quantities are placed in the brick boxes of a hydraulic press, Fig. 2, page 317. The moulding pressure used is generally between 10,000 lb. and 15,000 lb. per square inch. The drying of dolomite bricks has given rise to a number of difficulties, in spite of their low moisture content. The cause of these troubles is still rather obscure, but it is known that they can be minimised if the drying is done at as low a temperature as possible and in a stream of dry clean air. If the drying conditions are not right, considerable cracking of the bricks may occur either in the drier or during subsequent kiln firing.

The firing is carried out in down-draught kilns, either circular or rectangular, using coal, oil or producer gas as a fuel. The dolomite brick kiln shown in Figs. 3 and 4, opposite, is fired with producer gas. The maximum temperature is 1,400 deg. to 1,450 deg. C.

If insufficient firing treatment is given, *e.g.*, if a firing temperature of only 1,300 deg. C. is employed, some of the tricalcium silicate may break down in the manner already indicated and the product will then contain free lime. This may result in crumbling in storage. There is little doubt that some of the $3CaO.SiO_2$ in the clinker breaks down however dolomite bricks are fired, but considerable evidence obtained in both laboratory and works tests shows that any lime that may be formed in this way recombines during subsequent firing of the bricks at higher temperatures. A convenient indication of the firing treatment is afforded by the firing shrinkage, which is approximately $\frac{1}{8}$ in. on the 9-in. length of a standard square.

Manufacture of Special Dolomite Bricks.—Some of the earliest bricks to give useful service in steelworks (particularly in arc-furnace side walls) were of the semi-stable type. They contained large quantities of free lime, but could be stored long enough to make their use practicable and had a fairly good thermal-shock and slag resistance. Bricks of this type can be made by mixing " basic " with a flux or slag, moulding with a temporary bond, such as tar, and firing in the ordinary way. They are difficult to make and often difficult to store, but, as will be shown later, have a useful, if limited, application.

It has been shown that the replacement of the intermediate fraction in a stabilised-dolomite brick by dead-burned magnesite results in an increase in thermal-shock resistance. Thus a spalling resistance index of 30 reversals* can sometimes be obtained in this way, as compared with one or two reversals for the normal stabilised brick. The manufacturing technique of dolomite-magnesite bricks, apart from the change in batch composition, is similar to that of the ordinary brick. A great deal of work has been done on dolomite bricks made with additions of chrome ore. The change is purely one of batch composition, the object being to increase the thermal-shock resistance. At the other extreme, magnesite bricks have been made in which 20 per cent. or 40 per cent. of the magnesite was replaced by stabilised-dolomite clinker. Here, again, the manufacturing conditions for these magnesite-dolomite bricks are similar to those of magnesite brick-making, apart from the change in batch composition.

Properties of Dolomite Bricks.—The general properties of two typical stabilised dolomite bricks and of the magnesite bricks which they replace are shown in Table I. A selected analysis of one such brick is as follows :—

	Per cent.		Per cent.
Silica ...	... 14·44	Lime ...	... 40·04
Ferric oxide	... 3·44	Magnesia ...	... 40·30
Alumina	... 1·50	Loss on ignition	... 0·25

It will be seen that the porosity and permeability of such dolomite bricks are of the same order as those of the magnesite bricks, and that they show equally good volume stability at 1,500 deg. C. Their cold crushing strength is high, as is also their refractoriness under an unusually good thermal-shock resistance. Furthermore, its resistance to slags high in iron oxide and lime is greater than that of the ordinary stabilised-dolomite brick. It has, however, one serious limitation, viz., it can be stored for only a limited period.

A typical analysis of a specially graded dolomite-magnesite brick in which the stabilised clinker was replaced in the intermediate section by magnesia is as follows :—

	Per cent.		Per cent.
Silica ...	... 11·96	Lime ...	... 31·40
Ferric oxide	... 3·24	Magnesia ...	... 51·60
Alumina ...	... 1·60	Loss on ignition	... 0·14

The properties of this brick are summarised in Table II, column 2. The brick is similar in many respects to the stabilised-dolomite brick, but has a thermal-shock resistance of five reversals. Batches have been made of which the thermal-shock resistance was much higher, such as 15 to 30 reversals, but the problem of maintaining such values, both in brick-making and in use, is considerable. The specific heat of a brick of this type was found to be $0{\cdot}25_5$, while its thermal expansion (20 deg. to 1,000 deg. C.) was 1·26 per cent.

No description of dolomite-chrome bricks will be given, although a considerable amount of laboratory test data is available. They possess one serious limitation, viz., the tendency of the chrome to react at the working temperature with the dolomite clinker, with the production of a great deal of " melt." This results in serious softening, which has so far prevented their commercial application in steel furnaces. Trial batches of magnesite-dolomite bricks have been made in which 20 per cent. or 40 per cent. of the magnesite was replaced by stabilised-dolomite clinker. The properties of such bricks are summarised in Table II, columns 3 and 4. It will be seen that the samples examined had a low porosity, a high refractoriness under load and an usually high thermal-shock resistance. Slag tests using a 4/1 mixture of iron oxide and lime (representing basic open-hearth furnace dust) showed that these bricks had a slag resistance only slightly inferior to that of magnesite itself. The change in slag resistance on passing from magnesite to dolomite brick is illustrated in Fig. 5, opposite, in which is seen the results of tests on laboratory-made samples. The illustration shows the effect of a 4/1 ferric-oxide/lime " pill " on, from left to right, a 100/0, 80/20, 60/40, 40/60, and 0/100 magnesite-dolomite brick after 1 hour at 1,650 deg. C.

Application to Open-Hearth Furnaces in Steelworks.—As a result of trials made in 1935, 1936 and 1937 in open-hearth furnaces at the works of Messrs. S. Fox and Company, Limited, and at Templeborough, and similar tests made at Appleby-Frodingham, dolomite bricks have been widely applied in the open-hearth furnaces of The United Steel Companies, with a considerable saving in money in peace-time, and with an even more important saving in shipping at the present time.

Bath Bottom, Banks and Bridge Banks.—The encouraging results obtained with stabilised-dolomite bricks in tap-holes has led to a gradual replacement of magnesite bricks in fixed furnace hearths by dolomite bricks, until to-day the authors' company has no hesitation in building a new hearth without any magnesite bricks at all. With tilting furnaces, working the hot-metal process, the hearth is rarely seen, and hence it is not surprising that replacement has proceeded more

TABLE I.—*Properties of Basic Open-Hearth Furnace Bottom Bricks.*

Property.	Special Magnesite Brick. (No. M4.)	Ordinary Magnesite Brick. (No. M17.)	Typical Stabilised-Dolomite Bricks. (No. X6.)	Typical Stabilised-Dolomite Bricks. (No. X7.)
Apparent porosity	24·2	18·7	22·1	24·7
Bulk density :—				
G. per ml.	2·67	2·89	2·58	2·53
Lb. per cub. ft.	167	181	161	158
Apparent specific gravity	3·52	3·56	3·31	3·36
Cold crushing strength (9 in. by 4½ in. by 3-in. brick, on end) .. .. Lb. per sq. in.	7,170	> 8,300	> 8,300	5,090
Permeability to air (perpendicular 9 in. by 3-in. face, through 1 skin) .. .. C.g.s. units	0·08	0·12	0·088	0·12
After-contraction (2 hours, 1,500 deg. C.) Per cent.	1·0	0·1	0·0	0·2
Refractoriness under load (maintained-temp. test : 25 lb. per sq. in. at 1,600 deg. C.)	Failed in 11 min.	Not determined.	Failed in 32 min.	Failed in 11 min.
Rising-temp. test (50 lb. per sq. in.) :—				
Initial softening .. .. .. deg. C.	—	1,450	1,540	1,460
Rapid softening .. .. .. deg. C.	—	1,520	1,610	1,510
Fall .. .. deg. C.	—	1,540	1,680	1,600
Thermal-shock resistance (No. of reversals required to produce failure.)	> 30	7	2	3

TABLE II.—*Properties of Various Other Bricks Containing Dolomite.*

Property.	1. Semi-Stable Dolomite Brick.	2. 80/20 Dolomite-Magnesite Brick (Special Grading).	3. 80/20 Magnesite-Dolomite Brick.	4. 60/40 Magnesite-Dolomite Brick.
Porosity .. Per cent.	22·8	26·4	19·2	20·4
Bulk density .. G. per c.c.	2·52	2·50	2·79	2·72
Specific gravity (by porosity)	3·27	3·40	3·45	3·41
Crushing strength (9 in. by 4½ in. by 3-in. brick, on end) Lb. per sq. in.	3,680	4,700	8,740	7,380
Permeability (perpendicular to 9 in. by 3-in. face, through skin) .. C.g.s. units	0·29	0·36	0·121	0·097
After-contraction (2 hours, 1,500 deg. C.) Per cent.	1·2	0·7	0·2	0·7
Refractoriness under load (50 lb. per sq. in) :—				
Initial softening deg. C.	1,360	1,430	1,370	1,400
Rapid softening deg. C.	1,520	1,500	1,510	1,580
Fall .. .. deg. C.	1,610	1,700	1,650	1,710
Refractoriness under load (25 lb. per sq. in., maintained at 1,600 deg. C.)	—	10 per cent. deformation after 49 min.	—	—
Thermal shock resistance (No. of reversals required to produce failure)	23	5	15 >26	13 16 } 15
Slag resistance (when tested with " $4Fe_2O_3.CaO$," slag at 1,650 deg. C.)	Definitely higher than stabilised-dolomite brick. No " bursting " expansion with iron oxide.	Similar to that of stabilised-dolomite brick. No " bursting " expansion.	Only slightly inferior to magnesite. Show volume stability at this temperature.	

Other Types of Dolomite Bricks.—A selected analysis of a semi-stable brick is as follows :—

	Per cent.		Per cent.
Silica ...	... 4·27	Lime ...	... 51·66
Ferric oxide	... 2·53	Magnesia ...	... 38·21
Alumina	... 2·16	Loss on ignition	... 1·07

It will be seen that the material does not differ greatly in analysis from the ordinary " basic " used for fettling open-hearth furnaces. The properties of samples of this type are summarised in Table II, column 1. It will be seen that, in addition to a comparatively low porosity and moderately good crushing strength, the brick has a fairly high refractoriness under load and

In addition to the properties given in Table I, the following may be considered typical for the present-day stabilised-dolomite brick :—

Thermal expansion (20 deg. to 1,000 deg. C.)	1·31 per cent.
Thermal conductivity (1,000 deg. mean)	15 B.Th.U. (*cf.* magnesite, 25 B.Th.U.).
Specific heat (750 deg. to 20 deg. C.)	$0{\cdot}25_5$.
Hydration resistance	No crumbling after boiling in water for 24 hours.
Free lime	No free lime by the glycerol or White's test.

* The test methods used are those described by one of the authors (J. H. C.) in a recent article in *The Iron Age*, vol. 147, pages 33 and 47 (1941).

DOLOMITE BRICKS FOR STEELWORKS.

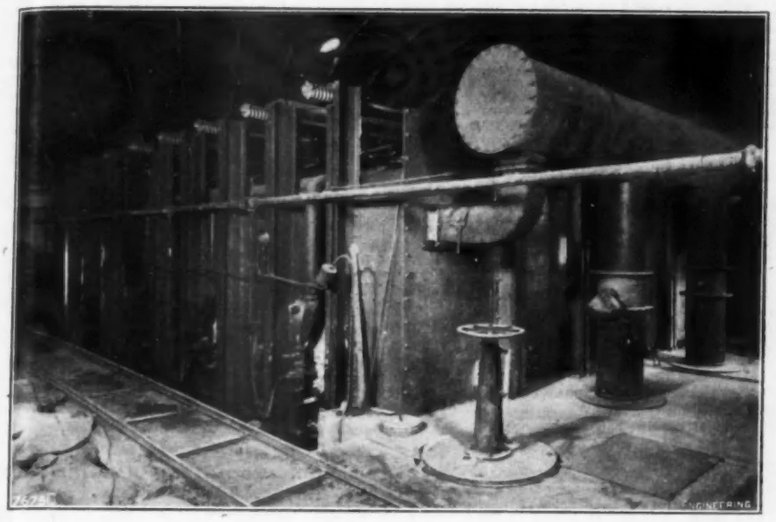


FIG. 3. PRODUCER-GAS FIRED DOLOMITE BRICK KILN.

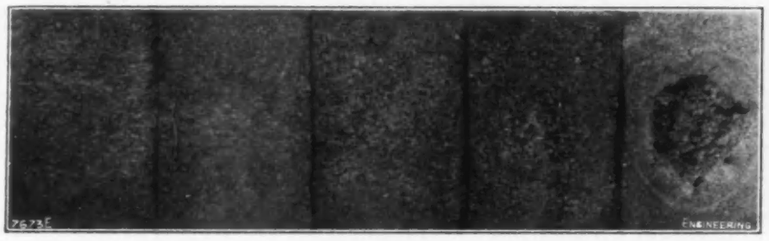


FIG. 5. SLAG TESTS ON BRICKS.

FIG. 4. SETTING IN DOLOMITE BRICK KILN.

gradually. It has been found, however, that stabilised-dolomite bricks can be used with fair success in the back banks where they can be seen and fettled, and, as a result, partial replacement of the hearth bricks has been tried. Thus, at one plant eight courses in the back wall around the furnace ends, four above and four below the sill, are used, the bricks extending for the full thickness of the lining. About 3,000 to 4,000 dolomite bricks are used for a normal repair in positions in which magnesite bricks were previously employed. In the front banks of tilting furnaces the use of dolomite bricks is more doubtful, since fettling is difficult.

The use of bricks in the sub-hearth is essentially an insurance against premature failure of the monolithic hearth, and hence, unless such failure actually occurs, the bricks are not subject to any real test. It will therefore be asked whether, in fact, break-outs have been more frequent when using dolomite bricks. Even if all other variables were controlled, a fair answer to this question could be given only after a long period of years. All that can be said at the moment is that, in the authors' experience, the break-outs on furnaces having dolomite brick hearths have actually been less in proportion to the number of hearths lined in this way than have been experienced with magnesite during the same period. In one case, where a break-out did occur through a sub-hearth consisting of dolomite bricks, the latter were critically examined in the laboratory. Chemical analysis showed that the iron-oxide content had increased in the top layers from about 3 per cent. to 17 per cent., and there had been a corresponding drop in the magnesia content. The silica was only 8·6 per cent., *i.e.*, less than in the original brick, presumably owing to the diluting action of slags high in iron oxide and lime. This result, which falls in line with later studies on open-hearth furnace bottoms, suggests that dolomite bricks used in this position tend to become similar in composition and texture to the adjacent "basic." There is, therefore, no reason to believe that, if a hearth wears thin enough to expose the dolomite bricks, there will be any increase in the rate of wear. Indeed, at one steelworks, where the conditions had been particularly bad, it was stated that the dolomite bricks had stood up better than would have been expected of magnesite bricks.

Tests were also made on the "break-out" hearth to see whether prolonged heating at about 1,200 deg. C. had resulted in any dissociation of the tricalcium silicate. The bricks showed no crumbling on boiling in water for 24 hours, and there is no reason to believe that they were any less stable after use than magnesite bricks. Indeed, the percentage recoveries from used magnesite and dolomite hearths would appear to be of the same order.

Back Walls.—Attempts to use ordinary stabilised-dolomite bricks above the hearth level have mostly resulted in premature failure, owing to spalling. More recently, bricks have been produced that have given more encouraging results. Thus, with the 80/20 type dolomite-magnesite brick, in which the magnesite is present in the intermediate section, back-wall trials in fixed furnaces showed a life of about eight weeks, as compared with eleven weeks for chrome-magnesite bricks. Still more encouraging results have been obtained with semi-stable bricks, which have recently given back-wall lives of the same order as chrome-magnesite bricks. These bricks still possess one serious limitation, viz., they must be used within a short time, although attempts are now being made to overcome this by impregnating the fired brick with organic stabilisers.

With tilting furnaces the position is more difficult, because the slag runs up the back wall during tilting. Some success has been obtained with small trials of stabilised-dolomite bricks, and more recently results approximately equal to those given by chrome-magnesite bricks have been obtained in trials of the 80/20 magnesite-dolomite type. Trials of semi-stable bricks are in hand, but it is too early to state whether these will be successful. Good results have also been obtained with stabilised-dolomite bricks in the splays of tilting furnaces. Considerable quantities of imported chrome and magnesite are also used for the parging of tilting furnaces. Preliminary trials, using finely ground stabilised clinker, suggest that a cement of this type may, with some development, provide an adequate substitute.

Reheating Furnaces.—Scale formation may be so serious in reheating furnaces working at 1,200 deg. C. and upwards that the use of firebrick hearths is precluded. In such hearths, the use of chrome-magnesite or magnesite bricks has been usual, but in the last few years, extensive use has been made of stabilised-dolomite bricks with complete success.

Cement.—Special cements have been developed for use with stabilised-dolomite bricks. They consist essentially of finely-ground stabilised-dolomite clinker, and can be used either wet or dry. No special precautions, such as the use of oil-bonded cements, are necessary with stabilised-dolomite bricks. With bricks of the semi-stable type, however, dry-setting or a non-aqueous cement must be employed.

EFFECT OF CUTTING OILS ON VARNISHES AND RUBBER PAINTS.

CUTTING oils, sometimes described as coolants, which are used in machining operations, tend to soften some insulating varnishes and paints which are used on electrical apparatus. As the matter may be of importance in manufacturing operations, the British Electrical and Allied Industries Research Association has published a report* dealing with a quantitative investigation on the subject. The work described was carried out by the Research Association of British Paint, Colour and Varnish Manufacturers.

The report deals with two independent series of tests. The first was made with a soluble cutting oil consisting of a mineral lubricating oil blended with emulsifying agents so as to give a stable product on dilution with water, black air-drying insulating varnish, and red chlorinated rubber paint being subjected to its effects. The varnish and paint were applied to flat steel panels, 6 in. by 3 in., by spreading with a scraper device; although the film thickness of wet varnish and paint was the same throughout, the thickness of the dry film varied greatly after various periods of drying. This was probably due to differences in the amount of volatile material in the paint and varnish. After drying at 60 per cent. relative humidity, and, in general, at 25 deg. C. for periods varying from 2 days to 15 days, the panels were immersed in the cutting oil, in a shallow dish, for periods varying from 15 minutes to 20 hours. The films were then tested for hardness by a rotating-point penetrometer. This instrument, which is described in detail in the report, forced a steel ball, 1 mm. in diameter, into the film at a load constantly increasing at the rate of 23 g. per second. During application, the ball was rotated at 2 r.p.m. Penetration was indicated by electrical con-

* *Effect of "Cutting" Oils on Insulating Varnishes and Chlorinated Rubber Paint.* Technical Report, Ref. A/T77. Price 5*s*.

nection being made between the ball and panel. The results showed the paint to be much superior to the varnish in resistance to the action of the cutting oil. For short periods of immersion the load required to cause penetration was at least twice as great for the paint and for one hour's immersion it was about six times as great. It was found that, allowing a minimum of 5 days, the age of the film had little influence on the penetration load.

In the second series of investigations, the hardness of the film was measured by a scratch-hardness tester; finger-nail tests were also employed. The series was considerably more extensive than the first, nine paints and varnishes being subjected to the influence of three proprietary cutting oils—Shellcut M3 soluble compound, Cooledge, and Adcol H.M. Aquicut. The materials tested were oil varnish, spirit manila varnish, bituminous varnish, phenolic resin varnish, alkyd resin varnish, shellac impregnating varnish, chlorinated rubber paint, shellac-glycol ether varnish, and shellac-glycol ether varnish with added shellac. The films were, as before, prepared on flat steel panels, 6 in. by 3 in., by spreading with a scraper. The majority of the films were of a thickness within the range 20μ to 30μ. With some of the materials, thicker films were obtained, but their behaviour after immersion in the cutting oil left no doubt about their position in the group, from the point of view of softening. As the first investigation had shown that five days' storage was sufficient for drying, this period was adopted as a standard, except in the case of shellac-glycol ether varnish, which showed slight tackiness after five days and was accordingly kept for seven days before test.

The prepared films were immersed in the cutting oil, at 25 deg. C. and 60 per cent. relative humidity for varying periods up to 100 hours. Observations on the change of hardness with immersion time were made in the first instance by scratching with the finger nail. This was found useful for broad differentiations, but was not sufficiently definite for a proper classification of the materials. Some films softened relatively gradually and judgment of breakdown time varied considerably with the nail pressure. An A.I.D. scratch-hardness tester was accordingly used. With this instrument the test panel is drawn under a 1 mm. diameter ball point to which definite loads can be applied. The hardness of the film is measured by the load which is just sufficient to cause the ball point to scratch through and make connection with the metal plate. This point is indicated by the completion of an electric circuit. All scratch-hardness tests were made at 25 deg. C. and while the panels were still wet with cutting oil, as it had been noted that some films hardened on drying. The panel was moved under the ball point at a uniform speed of 1 ft. per second; in some cases films showed a quasi-viscous flow so that although the penetration load was 200 g. under this standard condition, penetration occurred under a static load of 20 g. in 2 minutes.

In order to classify the various materials tested and to establish an order of merit, from the point of view of the particular property under investigation, the basis of comparison adopted was the time of immersion in cutting oil necessary to reduce the scratch-hardness load to 500 g. This resulted in the placing of the varnishes and paint in the following order:—Chlorinated rubber; copal resin (stoved); alkyd resin (stoved); spirit manila; shellac; alkyd resin (air-dried); shellac glycol-ether (stoved); copal resin (air-dried); shellac glycol-ether and shellac (air-dried); bituminous (air-dried); and phenolic resin (air-dried). The order was substantially the same for the three types of cutting oil. Some cutting oils oxidise freely on exposure to the atmosphere, as shown by their tendency to skin. Thus, a thin film of Adcol Aquicut solidified in half-an-hour at 25 deg. C. and 60 per cent relative humidity. Droplets of such oil would harden and might form a protective coating over a varnished surface. As the initial effect of absorption of cutting oil by some varnishes is a considerable increase in hardness, a fine and intermittent spray of such oil would probably do little harm, at least for a long time. Some varnishes, of which alkyd resin and shellac are examples, were restored to normal hardness within two days after removal of the surplus oil by washing in water; it is probable that they would be softened much less by an intermittent spray over a long period than by total immersion for a short time.

Engineering Bulletin.—The fourth issue of the new publication, *Engineering Bulletin*, which is issued by the Ministry of Labour and National Service, contains a number of interesting illustrated articles dealing mainly with the training of personnel for industry. The articles relate to problems of tool setting; the work being done by women in a Midlands factory; the value of protective clothing in accident prevention; and the Indian training scheme.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

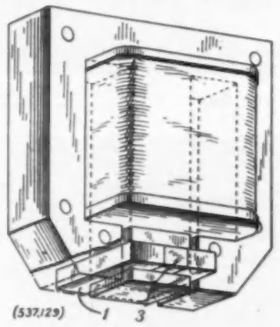
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

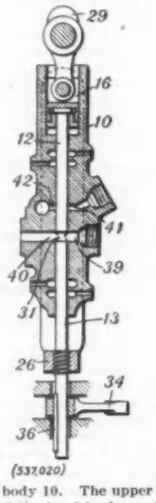
537,129. Watt-hour Meter Quadrature Band. Venner Time Switches, Limited, of New Malden, S. J. Matthews and A. W. Dean, of New Malden. (4 *Figs.*) December 12, 1939.—The magnitude of the eddy currents set up in the quadrature ring is dependent upon the ohmic resistance of the ring which is made of copper in order to have the lowest practicable resistance. Copper has a high temperature coefficient, however, so that the correction of the speed of the disc can only be accurate at a pre-



determined temperature. The quadrature band is a solid rectangular ring 1 composed mainly of copper, with a section of manganin 3 on one side. The latter has a low temperature coefficient compared with that of copper, whereas the copper portion of the ring has the required low specific resistance. The manganin section 3 is small in relation to the complete ring; for example, one third of the length of one side. The ring is shown mounted on the central limb of an E-shaped magnet. (*Accepted June* 10, 1941.)

INTERNAL-COMBUSTION ENGINES.

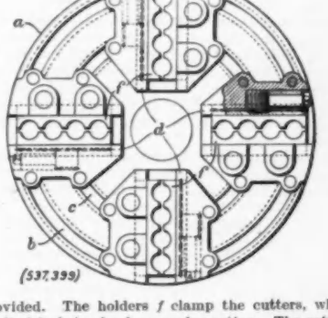
537,020. Petrol Feed. Aero Engines, Limited, of Bristol, and G. F. Halliday, of Bristol. (4 *Figs.*) November 30, 1939.—The invention is a petrol feed for supplying fixed quantities of petrol to the engine at each stroke. Two plungers 12 and 13 are a close sliding fit in



the bore of a fixed body 10. The upper end of the plunger 12 is headed and the head is clamped in a crosshead 16 which slides in an enlarged bore in the body 10. The crosshead 16 is coupled to a connecting rod by a transverse wrist pin which passes at each end through slots in the body. The projecting ends of the wrist pin engage a U-shaped yoke 26 into which is screwed the lower plunger 13. Both of the plungers are reciprocated in unison by a crankshaft 29 so that a constant space 31 is maintained between their adjacent end surfaces. This space 31 is adjustable by rotating the threaded plunger 13 in the yoke. This adjustment can be made while the feed is working by means of an arm 34 formed with a keyway engaging with a relatively long key 36 upon the plunger 13, the arm 34 being prevented from moving with the plunger. When the plunger 13 rises it completely isolates two opposite ports 39, 40 from each other. The port 39 is connected to a compressed air supply, while the port 40 leads to the induction pipe of the engine close to the inlet valve. Above the ports 39 and 40, and just below the top of the stroke of the lower end of the plunger 12 is another pair of diametrically opposite ports 41 and 42. These ports are mutually isolated by the plunger 12 at each downward stroke, the port 41 being connected to the petrol tank while the port 42 is an overflow to return surplus petrol to the tank. The crankshaft 29 is driven at one half engine speed for a four-stroke engine. As the plungers reach the top of their stroke, petrol from the port 41 fills the space 31 between them, any surplus being returned to the tank through the port 42. The plungers then move down until the space comes into register with the ports 39 and 40. The compressed air in the port 39 thereupon completely empties the space and forces the petrol through the port 40 into the inlet manifold. (*Accepted June* 5, 1941.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

537,399. Curved-Tooth Cutting Tool. Craven Brothers (Manchester), Limited, of Stockport, and W. Owen, of Stockport. (2 *Figs.*) October 4, 1940.—The tool will cut either right-hand or left-hand gears and any pitch and curvature of teeth using the simplest trapezoidal cutting tools. The face plate *a* is secured upon the revolving cutter spindle and has two concentric T-section slots *b* and *c*. Four, six or eight tool slides *d*, according to the size of the machine, are clamped to the faceplate, each slide housing a cutter holder *f* and a cutter which deals with one circular tooth flank of the gear being generated, so that in one revolution of the faceplate several tooth spaces are operated upon. The whole of the peripheral edge of the faceplate *a* is indexed and the outer ends of the tool slides *d* carry vernier scales to enable the angular position of each slide to be set with accuracy. Ordinarily the slides will be spaced equally around the faceplate, but minute individual adjustments may be made to produce backlash and corrected teeth. The cutter holders *f* can be adjusted radially by a worm and circular tooth rack. Each holder has equally spaced cutter positions and the radial adjustment is greater than the spacing of these positions so that cutter positions covering the whole radial width of the faceplate



are provided. The holders *f* clamp the cutters, which have cylindrical shanks, by a wedge action. The cutting end of each cutter is trapezoidal with flat flanks backed off. The cutters have the form of fly cutters used in worm-gear generating machines. Due to their cylindrical shanks the cutters can be turned to face in either direction, the faceplate *a* being revolved in that direction for the production of either right-hand or left-hand gears. The pitch of the teeth generated is controlled by the number of cutters which pass through the teeth per revolution of the gear being produced; the thickness and depth of the teeth and the width of the spaces are governed by the thickness of the cutters at the pitch line and their angular setting relative to one another and the distance which they protrude from the cutter holders upon the faceplate. Several thicknesses of cutters are provided with each tool. To obtain full-length tooth bedding, all the cutting edges of the cutters are set at the same radius, but if either middle or end bedding is required, the radius of the cutters which produce the convex flanks on one gear must be slightly less than the radius of the cutters which produce the concave flanks of the mating gear. (*Accepted June* 19, 1941.)